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A Study of Winter Disorders in Cows and Ewes Fed Low-Quality Roughage

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A Study of Winter Disorders In Cows and Ewes Fed Low-Quality Roughage

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Disorders among beef cattle and a high incidence of death losses, particularly among cows on winter rations, have frequently been reported in certain sections of Oklahoma. Disorders of a similar nature, associated with poor physical condition of cows, are not uncommon in many extensive grazing areas of the United States. In 1947, the Oklahoma Agricultural Experiment Station began an investigation into the causes of these losses. Field studies were made over a five-county area in eastern Oklahoma; and feeding tests and trials were conducted at Stillwater, using pregnant and lactating ewes as experimental animals.

Part I

FIELD STUDIES

Field studies were made during the later winter and early spring months of a five-year period, 1947-1952. These studies included surveys, direct observation of different herds, and discussions with cattle producers, veterinarians, and various agricultural groups. Data were obtained on the nature of the losses with respect to number of cattle, history and symptoms of affected animals, response to treatment, types of management and feeding practices, and other general conditions peculiar to the area being studied.

General Symptoms

A characteristic disorder among pregnant beef cows was found to account for most of the losses. The disorder was most frequently encountered in cows that were four to seven years old and in late pregnancy. First-calf heifers and aged cows were sometimes afflicted, but steers and non-pregnant cows within the same herd were rarely affected. Generally, as the main symptoms, cows were down and unable to get up (Figure 1). They were referred to by owners and other livestock men as "downer" cows. Emaciation and unthriftiness were usually, but not always, evident. The hair coat was rough, and the cows appeared dull and depressed. Temperature was normal. Rumination

Fig. 1.—Typical "downer" cow. This cow had been fed a winter ration consisting only of a poor quality prairie hay. She was due to calve in about three weeks, but died three days after the picture was taken.

was poor. The cows seemed to have little appetite although they were being offered "all they would eat" at the time of observation. Some cows, however, had a depraved appetite and were frequently observed chewing on boards, dirt, stones, and foreign objects. Such cows were thin and weak and appeared dull. Results of tests for anaplasmosis and other diseases were negative.

General Observations

Most of the cattle losses from the disorder occurred during the late winter and early spring months. February seemed to be the peak month. Acetonemia and digestive disturbances were also quite prevalent during the spring of the year. Troubles were encountered more frequently on sandy upland farms than on bottomland farms. Losses subsided almost entirely as soon as good quality grass became available. During the winter of 1946-47 the disorder was especially severe in certain areas. Reliable estimates of the actual number of cattle dying during that winter were hard to obtain, but losses of "several hundred" head occurred in one county. Another estimate placed the loss at two to five in many small-to-average-size herds.

A survey of one area, conducted in the spring of 1948 by seven Veteran Agriculture Training Program classes, revealed that approximately 20 cows in each township had died during the winter. Malnutrition, which would include the disorder of "downer" cows, was given as the apparent cause of death. When results from concurrent feeding tests with ewes by the Experiment Station were used as a basis for improving feeding and management practices, cattle losses during the winter period were greatly reduced. Only a few isolated cases were reported in the spring of 1952. The improved feeding and management practices consisted mainly of supplementing the native hay rations with protein concentrates, cereal grains, and minerals, and the liberal use of late fall and early spring legume and small grain pastures.

Rations and Feed

Early in the study there was evidence of the cattle being wintered at a low level of nutrition. Rations consisted mainly of poor to medium quality hay, with the cattle usually having access to dry native grass. Protein supplements were being fed to some of the herds; however, this was not a general practice. Frequently, protein supplementation had been started only one or two weeks before "downer" cows were observed. Minerals most commonly fed were salt and bonemeal. There was always some question about total feed intake of individual cows. Chemical analyses of hay collected from farms where trouble was encountered did not reveal anything unusual about its approximate composition (Table I).

Table I.—Average Chemical Composition of Hay from Farms Having Cattle Losses (1948).

Kind of hay	No. of samples	Dry matter (Percent)	Composition of Dry Matter (percent)				
			Ash	Protein	Ether extract	Crude fiber	N-free extract
Meadow (Prairie)	9*	93.84	6.37	5.23	2.26	36.44	49.70
Lespedeza	4	93.85	5.9	11.53	2.50	27.90	52.17

* Analyses of similar samples have shown 0.45 percent calcium and 0.06 percent phosphorus. Chemical analysis of 5 samples of hay showed the presence of .09 ppm. cobalt. The cobalt determinations were made by Dr. J. C. Street.

Table II.—Blood Constituents of Cows That Were Down, Thin or Weak. (Field Studies in Spring of 1947 and 1948)

Date	No. of samples	Calcium	Phosphorus	Magnesium	Carotene	Vitamin A	Hemoglobin
		mg/100 ml plasma			mcg/100 ml plasma		gm/100 ml
Mar. 10, 1947	17	9.5	4.6	1.7	275	14.4	6.9
Feb. 13, 1948	9	10.6	5.2	--	236	20.5	8.3
Mar. 17, 1948	7	--	--	--	---	---	7.2

Tissue Changes

Cattle suspected of dying or being ill as a result of specific infectious diseases were not considered in these studies. Blood samples for chemical examination were collected during February of 1947 and 1948 from typical "downer" cows in several herds. The most characteristic finding was low hemoglobin values (Table II). Examinations of fecal material from these animals and others in the herd, and of the abomasum of animals that died, demonstrated that parasites were not responsible for the symptoms. The urine of the "downer" cows usually gave a positive reaction to the Ross test for ketone substances. Post mortem examination of those that died of the disorder revealed various stages of fatty infiltration and degeneration of the liver. Other tissue changes, especially those caused by pneumonia, were sometimes present but these were believed to be secondary complications. The contents of the entire digestive tract were usually dry and hard.

Facts Supplied by Feeding and Chemical Tests

Feeding tests with hay from the troubled area confirmed many of the observations made in the field studies. These tests are described in Part II of this bulletin.

Malnutrition appeared to be the basic cause of trouble. Cattle owners, however, were not readily convinced, probably because the "downer" cows were being offered all they would eat and because other animals in the herd, being fed the same rations, were unaffected. In contrast, some of the owners were the first to suggest that the ration was at fault—that the roughage was deficient in some essential nutrients, as for example, protein, vitamin A, minerals, especially phosphorus and cobalt, or some other unknown substance. Blood analyses of "downer" cows and of ewes fed the same hay, however, failed to indicate that either calcium or phosphorus deficiency was the principal factor involved. The results of feed and blood analyses ruled out the possibility of vitamin A deficiency as being the specific cause of the disorder although such a deficiency could be caused by feeding old weathered hay. Cobalt deficiency could not be demonstrated by feeding tests with ewes, although it was indicated by symptoms, and by anemia, and the occasional response of cows to cobalt supplementation. Chemical analysis also indicated low levels of cobalt in the hay (Table I). Protein deficiency (and also lack of enough total feed) was suspected in field studies with cattle and was clearly demonstrated in the ewe-feeding tests.

Treatment

Some "downer" cows responded, at least temporarily, to calcium-gluconate and dextrose treatment. However, many of them (35 to 40 percent) went down again. Many of the repeat "downer" cows failed to respond to further treatment and eventually died. The few survivors were nursed back to health mainly by improving the ration. This consisted of stimulating the appetite by feeding protein supplements, minerals, and good-quality roughage, usually alfalfa hay. Cobalt sulfate was one of the minerals that seemed to be especially helpful in restoring the appetite of "downer" cows as well as the appetite of the rest of the cows in the herd. In some cases, rumen inoculation of the "downer" cows with rumen material from healthy cows appeared to be of some help.

RECOMMENDATIONS

It is of particular significance that the disorder with cows occurred at a time of the year when the quality and the quantity of the feed is lowest and the nutritive requirement of these animals is highest.

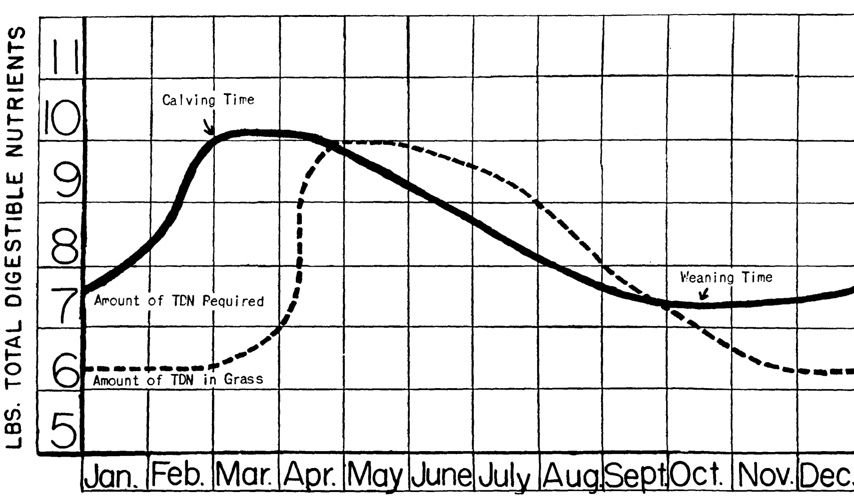

Fig. 2.—Chart illustrating the yearly feed requirements (expressed as T. D. N.) of an average 900-pound cow during reproduction and lactation in comparison to the total amount of feed that would be supplied by native grass. Note the high requirement near calving time. In this chart the cow requirements were figured from the National Research Council's recommended allowances for beef cattle (14); the composition of grass from a report by Savage and Heller (20) and the consumption and digestibility of pasture from the work of Garrigus and Rusk (8).

In most instances, under practical conditions, simply more feed at this time of the year would aid materially in preventing this disorder and related disturbances in cows. Special consideration, of course, should be given to feeds supplying protein. Protein concentrates, legume hay, and late winter or early spring legume or small grain pastures would be valuable supplements to the poor-quality roughages.

Other workers, especially Rusoff and Seath (19), Stafford (23), and Snell and associates (22) have reported similiar disturbances in cattle fed rations composed mainly of poor roughages. These workers also emphasized the importance of additional feed during the late winter and early spring months for the prevention of this trouble. Snell and associates reported that they were able to reduce the death losses of cows approximately 5 percent by the addition of concentrates to rations of poor-quality roughages. These workers figured a return of approximately $2 for every $1 invested in additional concentrates.

The total feed requirement of beef cows during the year as related to the amount of feed supplied by average quality native pasture is illustrated in Figure 2. Additional feed at certain times of the year will not only supply such critical nutrients as protein and phosphorus but will increase the efficiency of utilization of the grass by providing a more balanced ration.

Very little success was attained in treating the ewes and cows after they had reached advanced stages of weakness and loss of appetite. Therefore, consideration should be given to management and feeding practices that will prevent malnutrition. A preventive program

Fig. 3.—Low-quality winter feeds and poor management practices will allow serious nutritional disturbances to develop in cattle that are not only difficult to correct but may even cause heavy losses.

Fig. 4.—This beef cattle herd in Eastern Oklahoma was wintered only on good quality mixed lespedeza hay and an improved winter legume pasture. Cows are in excellent condition for calving.

should consist of making a close appraisal of the feed requirements for the cow herd during the winter months. Additional feed must be readily available for use during periods of unfavorable weather conditions. Particularly after a hot dry summer, dead pasture grass is so low in nutritive substance that it will need supplementation early in the fall. Where grass is sparse or unpalatable, concentrate feeds will spare the amount of protein supplement required to prevent excessive loss of weight. Winter (late fall or early spring) pastures will not only reduce feed costs materially but will also keep cows in good physical condition (See contrast in Figures 3 and 4). Feeds such as silages and good-quality roughages will also reduce the amount of the more expensive concentrates that would be required. Cows that start the winter in a thin condition, or those that calve early will require more feed than cows in good flesh. Attention should also be given to the feeding habits of individual cows. Crowded feeders or placing the feed in a restricted area may allow the more aggressive (and horned) animals to get more than their share of feed while timid cows are underfed.

Part II

FEEDING EXPERIMENT WITH EWES

Ewes were selected for these experiments because their nutritive requirements are similar to those of cattle and they can be handled experimentally with greater economy and ease. The general procedure was to feed rations during reproduction and lactation that were composed mainly of hay from the area in which the field studies were made. The value of various supplements to prevent or cure deficiencies produced by the hay ration was determined.

General Procedure

The hay fed to ewes in these experiments was considered typical of that fed on farms encountering cattle losses during the 1946-1947 winter. It was poor to fair quality native grass hay containing considerable stemmy and coarse material. It was grown on the same unfertilized meadow each year, cut, baled, and stored until fed the following fall. In this bulletin it is referred to as "experimental" hay.

Corn gluten meal was used to supply protein in the experiments because it is low in phosphorus and cobalt. It was all from the same shipment. Sorghum syrup was used in Experiment III as a low-protein, low-mineral, yet palatable source of energy. Starch was used to supply additional energy. Alfalfa ash which was used in two experiments was prepared by burning good quality green leafy alfalfa hay in an open container and further ashing in a muffle furnace. The chemical composition of the feeds used in the first three experiments is given in Table III.

Shortly before and during the breeding season preceding each experiment, all the ewes were fed the experimental hay free choice, plus a small amount of alfalfa hay or pasture, and about one-half pound of a

Table III.—Chemical Composition of Hay and Supplements Fed Ewes During Experiments I, II, and III.

Feeds	Dry matter (percent)	Composition of Dry Matter (percent)						
		Ash	Protein	Ether extract	Crude fiber	N-free extract	Ca	P
Experiment I, 1948-1949								
Experimental Hay*	94.28	5.78	4.74	1.90	38.80	43.06	.438	.075
Corn Gluten Meal	94.38	1.46	44.24	1.43	3.37	49.50	.027	.297
Experiment II, 1949-1950								
Experimental Hay**	93.98	7.58	5.66	1.95	34.02	50.79	.429	.083
Corn Gluten Meal	94.38	1.46	44.24	1.43	3.37	49.50	.027	.297
Corn (white)	92.78	1.51	12.26	4.48	1.25	80.50	.021	.383
Experiment III, 1950-1951								
Experimental Hay***	93.07	6.56	4.48	1.91	40.82	46.20	.56	.044
Corn Gluten Meal	92.62	3.00	45.50	1.65	4.69	45.14	.11	.57
Soybean Meal	91.47	7.29	48.14	---	---	----	---	---
Corn	89.30	1.44	9.27	4.74	1.65	82.88	---	---
Corn Syrup	82.62	2.37	.73	---	---	96.90	---	---

* Average of four composite samples. This hay contained .09 ppm. cobalt by chemical analysis See Table I.

** One composite sample.

*** Average of two composite samples.

concentrate ration per head daily. The ewes in the first experiment were bred to a purebred Dorset ram and those in Experiments II, III, and IV were bred to a purebred Hampshire ram. In each experiment the ram was turned in with the ewes on approximately October 1. Shortly after the breeding season, the ewes were divided into the different experimental groups in accordance with accepted experimental procedure and started on the experimental rations.

In each experiment, the ewes had easy access to the experimental hay, salt, and water at all times. They were all treated with phenothiazine at the start of the experiment. The ewes and lambs were housed in a closed barn but had access to an outside exercise lot except in severely cold weather. Records were maintained on ewes and lambs as to weight changes, physical condition, and general performance. Further details are given with each experiment. These experiments were conducted during the winters of 1948-49 to 1951-52.

Chemical Analyses

Blood and other tissue samples from the animals were collected at selected intervals for examination. Special attention was given to constituents that might account for symptoms displayed by cows in the field studies. The analytical methods used were as follows: Hemoglobin by Wong's acid hematin method (28); plasma vitamin A, and carotene by the Kimble method (12); inorganic plasma phosphorus by the Fiske and Subbarow procedure (7); and, blood sugar by Benedict's modification of the Folin-Wu method (3). An Evelyn photoelectric colorimeter was used in these determinations. Plasma protein was determined by the method outlined by Phillips **et al.** (15); liver vitamin A by the method described by Gallup and Hoefer (9); liver fat and glycogen by the procedure used by Jaffee **et al.** (10); and plasma calcium by the Clark and Collip method (5). A.O.A.C. methods were used in the analysis of the feeds (1).

Experiment I

This experiment was conducted to determine, (a) the gestation performance of ewes fed only the experimental hay, (b) the value of the addition of a protein supplement, and (c) the value of protein supplement plus a complex mineral mixture.

Thirty, two-year-old, thin Texas ewes weighing an average of 90.5 pounds were started on experiment October 26, 1948, shortly after the breeding season. They were divided into three lots and fed hay free-choice, plus the following supplements: Lot 1 (18 ewes), none; Lot 2 (6 ewes), 0.25 pounds corn gluten meal per ewe daily; lot 3 (6 ewes), same as Lot 2 plus bone meal, 0.03 pounds daily, and the trace minerals, iron, copper, cobalt and manganese. All lots had free access to salt.

It was anticipated that the ewes in Lot 1 would show deficiency symptoms, and as these developed various nutrients were to be given to determine their effectiveness in curing the deficiency.

RESULTS

The ewes started to lamb on February 8, 1949. By March 1, five of the eight ewes that lambed in Lot 1 had died either shortly before or after lambing. During this same three-week period, two other ewes in Lot 1 and two ewes in Lot 2 gave birth to lambs that died shortly after birth. The experimental rations in all three lots were then supplemented with an increased amount of protein concentrate. The reproduction performance of all ewes that had lambed by March 1 is given in Table IV.

As lambing time approached, the ewes in Lot 1 became weak, appeared depressed, and refused to eat. Some of these ewes died with symptoms of pregnancy disease (Figure 5); others were so weak at parturition that they died from secondary complications. As stated, after March 1, 0.5 pounds protein supplement was fed daily to each ewe in Lot 1. No additional ewes were lost in this lot; however, the lambs born during the early part of March were small and weak, and many of them died shortly after birth.

Table IV.—Reproduction Performance of Ewes That Lambed by March 1, 1949. (Experiment I)

Comparisons	Lot 1 Exper. Hay	Lot 2 Exper. Hay Corn Gluten Meal	Lot 3 Exper. Hay Corn Gluten Meal and Minerals
Number of ewes*	8	3	1
Weight (lb.) change during gestation	—22	—16.5	0
Lambs			
Number born	9	4	1
Number died	8	3	0
Birth weight (lb.)			
Single	7.6	8.5	10.6
Twins	5.2	6.3	---

* The experiment was started with 18 ewes in Lot 1, 6 ewes in Lot 2, and 6 ewes in Lot 3.

The remaining ewes in Lot 1 that were weak were treated in various ways. Treatments included additional concentrate feed, cobalt intravenous injections of glucose, and calcium gluconate with and without phosphorus, and glucose given orally. None of these treatments seemed of any value once pronounced symptoms of weakness and inappetence had developed. The ewes in Lots 2 and 3 reproduced satisfactorily; however, the lambs were small and weak, and many of them died. Those that lived grew very slowly. The value of feeding mineral supplement could not be determined by the small number of ewes that lambed during the first part of the experiment.

Table V gives the average levels of various constituents in the blood of all pregnant ewes up to March 1. Probably of most significance was the decrease in hemoglobin in all three lots. This was most pronounced in Lot 1. Blood sugar and plasma protein levels also decreased during the experiment in all lots and were the lowest in Lot 1. Blood sugar levels had dropped as low as 20 mg per 100 ml blood in some of the ewes that died in Lot 1. These ewes were very anemic. There

Table V.—Blood Constituents of Pregnant Ewes That Lambed by March 1, 1949. (Experiment I)

Date	**Lot 1** Exper. Hay	Lot 2 Exper. Hay Corn Gluten Meal	Lot 3 Exper. Hay Corn Gulten Meal and Minerals
	Blood Sugar (mg/100 ml)		
10-26-48	60	59	61
11-23-48	49	46	47
12-21-48	44	51	59
1-26-49	47	41	46
2-22-49	39	44	51
	Hemoglobin (gm/100 ml)		
10-26-48	12.0	9.8	11.6
11-23-48	10.5	10.3	11.2
12-21-48	8.5	7.2	7.7
1-26-49	8.2	6.6	9.6
2-22-49	7.2	6.8	9.3
	Plasma protein (gm/100 ml plasma)		
1-26-48	6.3	6.7	7.2
	Inorganic Phosphorus (mg/100 ml plasma)		
3-1-49	5.6	--	--
	Vitamin A (mcg/100 ml plasma)		
3-1-49	25.2	--	--

Table VI.—Daily Supplement Allowance (lbs.) for Each Ewe, in Addition to Experimental Hay Free-Choice. (Experiment II)

Supplement	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
		Last Four Weeks Gestation			
Starch	--	.75*	--	--	--
Corn (White)	--	--	.50*	.50*	.50*
Corn Gluten Meal	--	--	.25	.25	.25
Dicalcium Phosphate	--	--	--	.031	.031
Trace Minerals (Fe, Cu, Co, Mn)	--	--	--	--	+
Cod Liver Oil	--	--	--	--	5 ml/wk.
		During Lactation (42 Days)			
Starch	.75	.75	--	--	--
Corn (White)	.50	.50	1.00	1.00	1.00
Corn Gluten Meal	--	--	.25	.25	.25
Dicalcium Phosphate	--	--	--	.031	.031
Trace Minerals (Fe, Cu, Co, Mn)	--	--	--	--	+
Cod Liver Oil	--	--	--	--	5 ml/wk.

* From start of experiment until four weeks previous to parturition, Lot 2 had been fed 0.5 lb. starch and Lots 3, 4 and 5 had been fed 0.25 lb. corn.

was no evidence of a deficiency of vitamin A or phosphorus. The experiment demonstrated that ewes could not reproduce satisfactorily on a ration composed of the experimental hay. Corn gluten meal, at the level fed, and minerals were only partially effective in preventing the disorders incurred by restriction to the experimental hay ration.

Experiment II

This experiment was essentially an extension of Experiment I. It was designed to determine the value of further supplementation of the experimental hay ration. Observations were made during gestation and lactation periods.

Thirty head of four- and five-year-old western Texas ewes were equally divided into five lots after being bred and were fed the experimental rations shown in Table VI. The average weight of the ewes at the start of the experiment on November 1, 1949, was 104 pounds. During gestation the Lot 1 ewes were fed only the experimental hay; Lot 2 was fed the hay supplemented only with corn starch for energy; Lot 3 was fed hay supplemented with corn and corn gluten meal which supplied a similar amount of energy as the starch, but

Fig. 5.—Ewe 67, Lot I, Experiment II, with symptoms of pregnancy disease. She was due to lamb in approximately two weeks. She was carrying twin lambs and had lost over 35 percent of original body weight. The liver on analysis contained 16.3 percent fat (fresh basis) and 2.2 percent glycogen.

additional protein; Lot 4 was fed the same ration as Lot 3, plus dicalcium phosphate, and Lot 5 was fed the same ration as Lot 4 plus 5 ml cod liver oil per ewe each week and the trace minerals—iron, copper, cobalt, and manganese. When starch was fed it was mixed with an equal amount of ground prairie hay.

During lactation the supplements were increased as shown in Table VI. At the termination of the experiment the ewes were slaughtered and tissues were collected for analysis and examination.

Results

The ewes lambed during the latter part of February and the first part of March. The reproduction-lactation results are given in Table VII. Near lambing time, two ewes in Lot 1 died and one aborted. One ewe in Lot 2 died at lambing time. These four ewes on low-protein rations had lost an average of over 30 percent of their original bodyweight. Symptoms were similar to those noted in the ewes that died during Experiment I (Figure 5). The livers from the three ewes that died contained an average of 19.8 percent fat and 2 percent glycogen (fresh basis). They were each carrying twin lambs. The lambs born in Lots 1 and 2 (low protein) were small and weak, and many of them died shortly after birth apparently from an inadequate

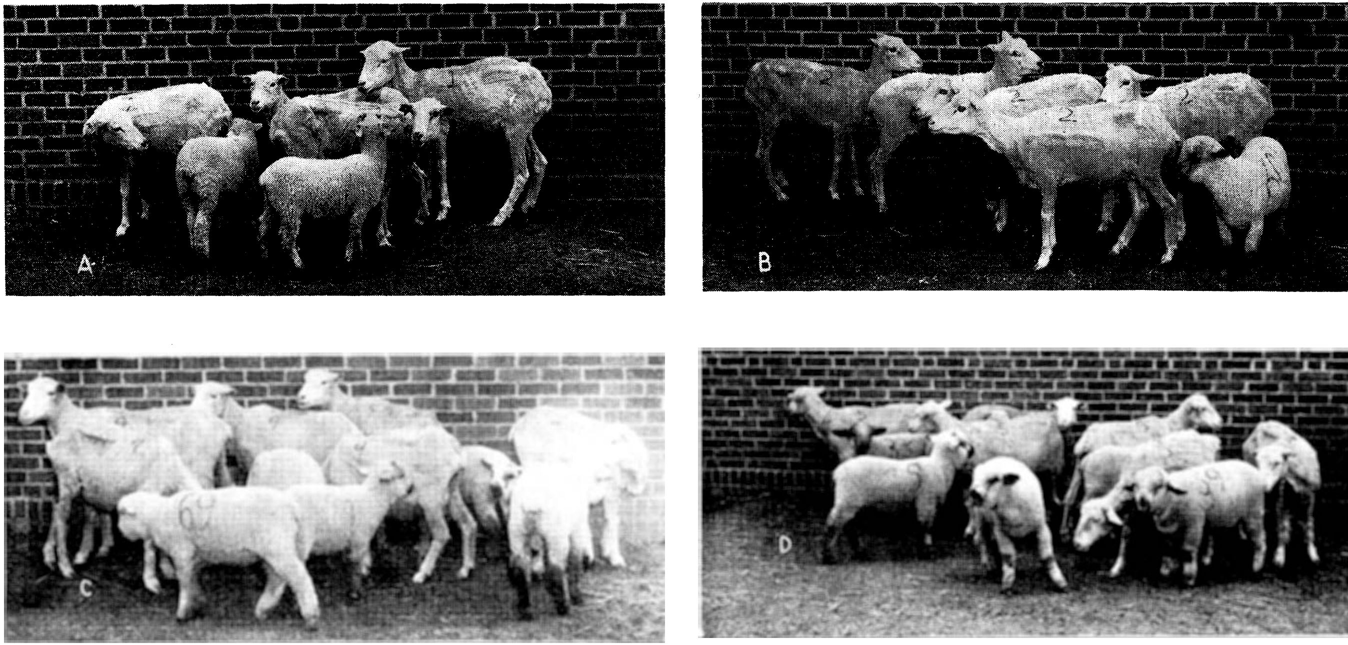

Fig. 6.—These are the ewes and lambs in Lots 1, 2, 4, and 5 of Experiment II. Lambs were 10 weeks old. (A) Lot 1 received a basal ration (mainly experimental hay). Two ewes and five of the seven lambs born were lost at lambing time. Surviving lambs weighed 15.5 pounds at 6 weeks. (B) Lot 2 received a basal ration plus starch and corn. One ewe and six of the eight lambs born were lost at lambing time. Surviving lambs weighed 20.1 pounds at 6 weeks. (C) Lot 4 received a basal ration plus corn gluten meal and phosphorus. Reproduction and lactation were normal. Single lambs weighed 27.8 pounds and twins weighed 17.2 pounds at 6 weeks of age. (D) Lot 5 received the same as Lot 4 plus cod liver oil and trace minerals Co, Mn, Cu, and Fe. Reproduction and lactation were normal. Lambs averaged 31.4 pounds at 6 weeks.

supply of milk furnished by the ewe; those that lived grew very slowly (Figure 6).

Results of tissue analyses are given in Table VIII. Although hemoglobin and plasma protein values tended to decrease in all lots toward the end of lactation, the decreases were most pronounced in Lots 1 and 2. Hematocrit values (not reported) paralleled the trend of hemoglobin values and were the lowest in Lots 1 and 2. At slaughter the livers from the ewes in Lots 1 and 2 were much smaller than those from ewes in the other three lots.

Additional energy in the form of corn starch failed to promote satisfactory reproduction and lactation. The addition of a protein supplement, corn gluten meal, gave satisfactory reproduction-lactation results (as measured by lambing results and growth rate of the lambs) which were not improved further by the addition of phosphorus, a trace mineral mixture or cod liver oil to the ration. The levels of calcium, phosphorus, and vitamin A in the blood, and the vitamin A content of the livers of the ewes in Lots 1 and 2 indicated that these nutrients were not involved in the poor performance of the ewes.

Table VII.—The Reproduction-Lactation Performance of Ewes During Experiment II. (Averages in Each Lot)

Comparisons	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Ewes					
Net Wt. Change (lbs.)					
During Gestation	— 27	— 18.7	— 4.6	— 0.2	— 1.1
During Lactation*	— 1	— 5.9	+ 5.8	— 1.5	+ 0.1
Wool Production (lbs.)	5.67	6.26	5.55	7.41	7.26
Liver Wt., Slaughter (gm)	433	403	590	606	602
Lambs					
Number born	7**	8	8	7	6
Died 1st part lactation	5	6	2	0	0
Birth wt. (lbs.)					
Singles	8.2	7.7	10.3	10.7	11.7
Twins	5.0	4.6	7.7	7.5	---
Wt. 42 days (lbs.)					
Singles	15.5	20.1	28.0	27.8	31.4
Twins	---	---	17.5	17.2	---

* Ewes weighed after lambing and after 42 days of lactation.
** Only four ewes.

Table VIII.—Tissue Analyses of Ewes in Experiment II. (Averages in Each Lot)

Date	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
		Hemoglobin (gm/100 ml)			
12-30-1949	9.6	10.7	12.0	11.1	11.6
2-2-1950	8.2	9.1	11.9	10.9	11.3
2-28-1950	9.1	8.6	12.3	11.0	11.5
3-17-1950	8.5	8.8	10.4	10.1	10.1
4-4-1950	8.3	7.2	10.8	10.1	9.7
4-22-1950	7.5	6.0	10.6	9.2	9.9
5-4-1950	8.0	6.2	9.6	9.8	10.3
		Plasma Protein (gm/100 ml plasma)			
2-2-1950	6.27	5.37	6.73	6.50	6.53
2-28-1950	6.18	5.82	6.86	6.86	6.79
3-17-1950	5.69	5.73	6.90	6.66	6.66
4-4-1950	5.69	5.81	7.12	6.86	7.12
4-20-1950	5.60	6.04	7.18	6.86	7.12
5-4-1950	5.98	6.28	7.31	7.18	7.31
		Plasma Inorganic phosphorus (mg/100 ml plasma)			
2-2-1950	5.39	4.75	4.52	5.94	4.78
2-28-1950	4.34	4.36	4.43	5.28	5.08
3-31-1950	4.80	5.96	4.70	5.51	4.57
4-13-1950	4.11	6.85	3.94	3.83	4.05
4-28-1950	4.41	6.16	4.80	4.49	4.70
		Plasma Vitamin A (mcg/100 ml plasma)			
3-1-1950	13.7	16.5	19.0	15.9	22.1
3-31-1950	19.7	19.4	24.5	22.4	26.6
4-13-1950	21.1	23.7	21.9	21.3	24.1
4-28-1950	23.8	17.5	21.5	20.0	22.6
		Liver Vitamin A (mcg/gm fresh liver)			
5-4-1950	245.8	281.5	128.1	138.4	174.8

Experiment III

In this experiment, observations were made on the value of supplementing the experimental hay with the following items: An increased amount of energy supplied in a more palatable form than starch; soybean meal compared to corn gluten meal as a protein supplement; alfalfa ash and cobalt as minerals with corn and corn gluten meal in the ration.

Thirty western Texas ewes, five and six years of age, were divided equally into five lots after the breeding season and fed the experimental hay supplemented as shown in Table IX. The average weight of the ewes at the start of the experiment was 99.7 pounds.

Table IX.—Daily Supplement Allowance (lbs.) for Each Ewe, In Addition to Experimental Hay.

(Experiment III)

Supplement	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
Start of Experiment Until Six Weeks Before Parturition					
Corn	.2	.3	.3	.3	.3
Corn gluten meal	--	.35	--	.35	.35
Soybean meal	--	--	.3	--	--
Sorghum syrup	.2	--	--	--	--
Corn starch	.2	--	--	--	--
Cobalt*	--	--	--	+	--
Alfalfa ash**	--	--	--	--	+
Last Six Weeks Gestation					
Corn	.4	.7	.7	.7	.7
Corn gluten meal	--	.4	--	.4	.4
Soybean meal	--	--	.35	--	--
Sorghum syrup	.4	--	--	--	--
Corn starch	.4	--	--	--	--
Cobalt*	--	--	--	+	--
Alfalfa ash**	--	--	--	--	+
Lactation (56 days)					
Corn	.5	.9	1.00	.9	.9
Corn gluten meal	--	.5	--	.5	.5
Soybean meal	--	--	.4	--	--
Sorghum syrup	.5	--	--	--	--
Corn starch	.5	--	--	--	--
Cobalt*	--	--	--	+	--
Alfalfa ash**	--	--	--	--	+

* Fed as cobalt sulfate to supply 1 mg cobalt per ewe daily.
** Fed amount equivalent to 0.5 pound alfalfa hay per ewe daily.

Corn was fed with the hay in all rations. All lots were provided with cod liver oil and dicalcium phosphate. Ewes of Lot 1 were fed a supplement of starch, and sorghum syrup (ratio of 1:1) mainly as a source of energy. Thus, this ration was low in protein and trace minerals, but equal to the other rations in energy and sufficiently palatable that ewes would eat it. Soybean meal, a high-quality protein, and corn gluten meal were compared as protein supplements for Lots 3 and 2, respectively. Cobalt was included in the ration for Lot 4 because of certain deficiency symptoms (inappetence, anemia, and unthriftiness) noted in field studies and because of the occasional response of cattle to cobalt supplementation. Alfalfa ash was added to the ration of Lot 5 because of reports by Ohio (4) and Pennsylvania (24) workers that it improves the utilization of poor-quality roughage. The amount fed was equivalent to 0.5 pounds of alfalfa hay per ewe daily. The total crude protein in the rations of Lots 2 through 5 was approximately 6.5, 7.8 and 8.5 percent during early gestation, the last six weeks of gestation, and lactation, respectively.

The amount of hay and concentrate consumed by each lot was measured. The hay was offered at the rate of 3 pounds per ewe and the amount refused was weighed back. Any refused concentrate was removed and weighed.

Results

The reproduction-lactation results of Experiment III are summarized in Table X. In Lot 1 (low protein) only five ewes lambed. During gestation the ewes in this lot lost even more weight than those fed only the exeprimental hay in the previous experiment. However, no ewes were lost at lambing time in this experiment. Lots 2, 3, 4, and 5, all receiving supplemental protein, performed equally well during reproduction and lactation. The ewes lambed during the latter part of March and the first part of April.

The average hemoglobin values of the ewes in each lot are given in Table XI. There was a progressive decrease in hemoglobin values starting about lambing time and continuing until the end of lacta-

Table X.—The Reproduction-Lactation Performance of Ewes in Experiment III. (Average in Each Lot)

Comparisons	Lot 1 Exper. Hay plus Energy	Lot 2 Exper. Hay Corn Corn G. M.	Lot 3 Exper. Hay Corn Soybean M.	Lot 4 Ration Lot 2 plus Cobalt	Lot 5 Ration Lot 2 plus Alf. Ash
Ewes					
Net wt. change (lbs.)					
During gestation	—29.4	— 3.6	— 0.2	— 7.2	+ 0.5
During lactation	—11.7	+ 0.8	— 9.2	— 0.8	— 7.2
Wool production (lbs.)	5.5	7.9	7.0	7.5	8.0
Lambs					
Number born	6*	8	8	8	7
Died 1st. Part Lactation	3	1	0	2	0
Birth wt. (lbs.)					
Singles	7.1	10.9	9.9	10.0	9.5
Twins	4.6	8.2	7.5	6.5	8.2
Wt. 56 days (lbs.)					
Singles	13.7	39.5	32.7	35.7	35.6
Twins	---	23.0	26.2	20.5	25.0

* Five ewes.

tion in all lots. The values for ewes fed alfalfa ash changed the least. Hematocrit and plasma protein values closely paralleled the hemoglobin values.

Average daily hay consumption by Lots 1 through 5 was 2.43, 2.66, 2.54, 2.72 and 2.53 pounds, respectively. The ewes of Lot 1 refused approximately half of their daily allowance of concentrate. Their lack of appetite for concentrates was particularly marked during lactation. None of the other lots refused the concentrate ration.

Experiment IV

This experiment was essentially a study of the comparative value of different protein and nitrogen supplements and a comparison of the experimental hay with hay from another source. Specific observations included: The value of urea (with and without alfalfa ash) as compared to hyraulic-processed cottonseed meal for supplementing a prairie hay ration; the value of a low-fat, solvent-processed cottonseed meal as compared to hydraulic cottonseed meal; and the value of prairie hay grown in west central Oklahoma as compared to the experimental hay.

Sixty-six Texas ewes, purchased in the fall of 1950 and used in other earlier experimental work, were bred to purebred Hampshire rams, divided equally into six groups, and started on experimental rations November 17, 1951. The average weight of the ewes was 113

Table XI.—Hemoglobin Values of Ewes in Experiment III. (Average in Each Lot)

Date	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
		gm/100 ml blood			
11-4-1950	11.7	11.1	11.1	10.7	11.3
12-2-1950	12.2	11.9	12.3	12.4	11.5
12-30-1950	11.5	11.0	11.9	11.0	11.6
1-27-1951	10.1	11.1	10.9	9.9	11.2
2-24-1951	8.9	9.7	9.5	9.5	10.0
3-24-1951	8.6	9.4	10.0	9.7	10.1
4-21-1951	4.6	7.3	6.9	7.1	9.6
4-30-1951	5.4	8.2	7.2	8.1	9.7
5-24-1951	6.1	8.0	7.1	6.6	7.5

pounds. The ewes in Lots 1 through 4 were fed a good-quality prairie hay. The ewes in Lots 5 and 6 were fed experimental hay from the same supply as used in Experiment III. In this experiment the concentrate ration with supplements was fed in a pelleted form. The composition of the pellets is given in Table XII. The ewes of Lot 1 were fed low-protein ration. Lot 2 was fed additional nitrogen in the form of urea and lot 3 was fed the same ration plus alfalfa ash. Lot 4 received hydraulic-processed cottonseed meal and Lot 5 received solvent-processed cottonseed meal in the pelleted concentrates. Lot 6 received the same concentrate pellet as Lot 4 but a different hay. Thus, it was possible to compare the value of hay from two sources (Lot 4 versus

Table XII.—Percentage Composition of Pelleted Concentrate Fed to Ewes in Experiment IV.

Ingredient	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
Corn	84.9	82.9	81.7	69.3	69.3	69.3
Cottonseed meal (hydr.)	3.9	3.9	3.9	19.8	---	19.8
Cottonseed meal (solvent)	--	---	---	---	19.8	---
Urea ("Two-Sixty-Two")*	--	2.0	2.0	---	---	---
Molasses	9.9	9.9	9.7	9.9	9.9	9.9
Alfalfa ash	--	---	2.4**	---	---	---
Bone meal	1.1	1.1	0.3	---	---	---
Limestone	0.2	0.2	---	1.0	1.0	1.0

* A commercial preparation of urea.
** Calculated to supply equivalent of 0.5 pound alfalfa hay per ewe daily.

Table XIII.—Chemical Composition of Feeds Used in Experiment IV.

Feeds	Percent Dry Matter	Percentage Composition of Dry Matter						
		Ash	Crude protein	Ether extract	Crude fiber	N.F.E.	Ca	d
Prairie hay (El Reno)	92.42	8.04	6.12	2.66	32.15	51.03	.39	.12
Prairie hay (Exper.)*	91.60	6.72	5.56	1.98	35.37	50.37	.44	.08
Cottonseed meal (hydr.)	93.47	6.74	42.86	7.32	12.44	30.64	.25	1.24
Cottonseed meal (solvent)	91.78	6.30	44.91	.69	13.42	34.68	.16	.87
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

* Same supply of hay as used in experiment III.
**Additional cottonseed meal was fed to equalize protein of concentrates for lots 4 and 6

Lot 6) and to compare low-fat, solvent-processed cottonseed meal with hydraulic-processed cottonseed meal (Lot 5 versus Lot 6).

Calcium and phosphorus supplements were included in the concentrate pellets in amounts to meet the N.R.C. recommendations (13). Salt and bonemeal (ratio of 1:1) were offered free-choice to each lot. Each ewe was fed 1.1 pounds of the pelleted concentrates until the seventh day after lambing and 2 pounds from that time until the forty-second day of lactation. Composition of the feeds is given in Table XIII. The hay was fed free-choice in weighed amounts. From the weigh-back of refused hay, consumption by lots during gestation was estimated. It was calculated that the protein content of the total ration for Lots 1 through 6 was 7.0, 8.8, 8.5, 8.6, and 8.5 percent, respectively. Ewes having twin lambs were given the larger lamb to raise as a single.

Results

A summary of the reproduction-lactation results is given in Table XIV. The results indicate that the low-protein concentrate was inadequate for the lactating ewe as measured by the growth-rate of the lambs. The addition of urea gave results equal to those obtained with cottonseed meal. Alfalfa ash was apparently of little value in improving the utilization of urea nitrogen. The ewes fed the experimental hay

Table XIV.—Reproduction-Lactation Performance of Ewes During Experiment IV. (Averages in Each Lot)

	"El Reno" Prairie Hay				East Okla. Exper. Hay	
Comparisons	Lot 1 Low Protein	Lot 2 Urea	Lot 3 Urea Alfalfa Ash	Lot 4 Hydr. C.S.M.	Lot 5 Sol. C.S.M.	Lot 6 Hydr. C.S.M.
Ewes						
Number						
Net wt. change (lbs.)						
During gestation	+ 2.3	+ 6.2	+ 6.1	+ 7.9	— 1.4	— 2.4
During lactation	— 1.9	+ 2.4	+ 5.5	+ 2.5	+ 1.0	+ 9.4
Wool production (lbs.)	8.5	8.1	8.3	8.7	8.1	7.8
Lambs						
Birth wt. (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
Net gain to 42 days (lbs.)						
Singles	22.9	26.9	26.2	27.2	22.7	27.8

performed as well as those fed hay from another source. Lambs in the solvent-meal lot grew slower than those in the hydraulic-meal lot. Whether or not this might be a true indication of differences in the cottonseed meal reflected in the milking ability of the ewes will have to be determined by further investigations. It has been suggested that lambs nursing ewes fed a poor-quality roughage and a low-fat concentrate supplement might develop "stiff-lamb" disease. No symptoms of a disturbance of this nature were observed in the lambs nursing the ewes in Lot 5.

Blood samples from five representative ewes in each lot showed the same progressive decrease in hemoglobin that had been noted in previous experiments. Hemoglobin decreased from values of approximately 13.6 gm per 100 ml at the start of the experiment to about 9.2 gm per 100 ml at the end of lactation and were the lowest in Lots 1 and 5.

DISCUSSION AND SUMMARY OF RESULTS

The disturbances encountered in the ewes fed the experimental hay without protein were similar in many respects to the disorders noted in cattle during the field studies. While some specific symptoms would probably vary between pregnant ewes and pregnant cows, a summary of the results of the four feeding experiments with ewes and the general application of these findings to the disturbance noted in cows in the field studies might be made.

Value of Supplements to Hay

The addition of energy supplements to the experimental hay ration was of little value in preventing the poor reproduction-lactation performance of ewes. When sufficient protein supplement was fed there was no evidence of improved reproduction-lactation performance by supplementation of the ration with calcium, phosphorus, cobalt and other trace elements, vitamin A or D, or by improvement in the quality of protein. There was inconclusive evidence that alfalfa ash might be beneficial in preventing anemia during lactation. Additional evidence that the trouble encountered with both ewes and cows fed low-quality roughage was not due to a phosphorus, calcium, or vitamin A deficiency was shown by the blood values of these constituents in afflicted animals. A phosphorus deficiency might be expected; however, in phosphorus-deficient cows Ross and associates (18) found much lower blood levels than those observed in these studied. Symptoms were not typical of an uncomplicated phosphorus deficiency. Protein supplement appeared to be the limiting factor.

In the field studies with cows, many of the symptoms observed were similar to a cobalt deficiency as described by Baltzer and co-workers (2). The cows had low hemoglobin and responded in some instances to cobalt supplements, especially as regards appetite, although a specific cobalt deficiency could not be demonstrated with ewes. Chemical analysis for cobalt in the hay indicated the need of further investigations of possible cobalt deficiency. Quality of protein did not seem to be involved—only the quantity. Part of this protein requirement of ewes was effectively supplied by urea.

The results of hay comparisons in Experiment IV indicated that there was nothing specifically at fault with the experimental hay.

Symptoms

No unusual symptoms were observed in ewes (or their lambs) that were fed the experimental hay supplemented with protein. Symptoms discussed below are those observed in cows and ewes fed mainly poor quality roughage and those observed in lambs born to ewes on low-quality roughage.

Ewes

Symptoms were observed most frequently in the ewes shortly before, or at lambing time. Loss of weight, weakness, and a poor appetite, especially for concentrates, were the most pronounced symptoms. Several ewes lost nearly 50 percent of their weight from the time the experiment started until after lambing. Of the 24 ewes fed the low protein rations, eight died either shortly before or at lambing time. Four of these ewes died with symptoms of pregnancy disease as described by Roderick and Harshfield (17). These ewes were carrying twin lambs and appeared to be in better flesh than other ewes in the same lot. The other ewes died apparently from miscellaneous complications at lambing time. Other conditions noted were lack of maternal instinct and poor milking ability at lambing time, listlessness, and shedding of the fleece. The weakness, and also the depression, were usually progressive—that is, for several days in succession certain ewes would have difficulty in getting up and walking; other ewes would suddenly go down and be unable to get up. They would refuse feed. The similarity of many of these symptoms with those observed in cows in the field studies was striking.

The most pronounced blood changes in the ewes fed the low-protein rations were lowered hemoglobin and plasma protein values. Low hemoglobin values were also observed in affected cows in the field study. Ewes had livers approximately 30 percent below normal size. Atrophy and fibrosis of the liver were evident. Dalgarno and associates (6) have reported that serum protein in ewes parallel the plane of nutrition. Tissue changes reported by Jolliffe, Tisdall and Cannon (11), as indicative of a protein deficiency, were similar to those reported here. It is believed that hemoglobin and plasma protein values may be only slightly lowered and still be more indicative of a protein deficiency than is generally realized. Low blood sugar values observed in the ewes were probably the result of secondary changes which occurred mainly during the late stages of the deficiency. Wool production by the ewes was reduced both in quality and quantity.

Lambs

In general, the symptoms closely resembled those described by Snell (21), Wallace (27), Thomson and Thomson (25) and Underwood and associates (26) for lambs born to ewes fed at a low plane of nutrition. Some lambs that appeared healthy and vigorous at birth died, apparently of starvation, soon after birth. Other lambs were very small at birth and were dead or died shortly afterwards. Only eight lambs were raised out of 30 born to the ewes fed the low-protein rations.

Cows

It is probable that multiple nutritional deficiencies account for the symptoms observed in cows in the field studies. Stage of pregnancy and degree of malnourishment would determine the severity of symptoms observed. Many of the symptoms in cows, however, were similar to those observed in the ewes fed only the experimental hay. Most evident similarities were time of disorder, weakness, loss of appetite (especially for concentrates), and anemia. There was no evidence of an effect on the size or vitality of the calf. Low level of feeding during gestation is apparently not reflected as much in the calf as it is in the lamb. For example, in another experiment at this Station (16), cows wintered at a low plane of feeding had calves just as large at birth (and a 100 percent calf crop) as those wintered at a higher plane. The cows on the low plane of winter feeding lost approximately 28 percent of their body weight during the winter months. The physical condition of the cow at the start of pregnancy undoubtedly has a bearing on how much weight can be lost before it is reflected in the size of the calf, or before serious nutritional disturbances occur.

GENERAL CONCLUSIONS

The results of these experiments and the field studies in eastern Oklahoma seem to warrant the conclusion that protein deficiency is the most important nutritional factor contributing to the disorder of "downer" cows. Problems of management and breeding, however, may be associated with this condition and related disorders.

While a vitamin A deficiency was not shown to be primarily responsible in these losses, it might be under drought conditions, or whenever roughages are fed that lack green color. Phosphorus deficiency, which usually accompanies protein deficiency, should not develop unless the animals refuse to consume phosphorus supplements. Other possible mineral deficiencies, none of which was indicated in the feeding tests with ewes, can be guarded against by feeding mineralized salt.

Protein deficiency slowly depletes body reserves. Unless corrected, it may lead to serious complications and such generalized weakness and inappetence that affected animals fail to respond to improved nutrition or other treatment.

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