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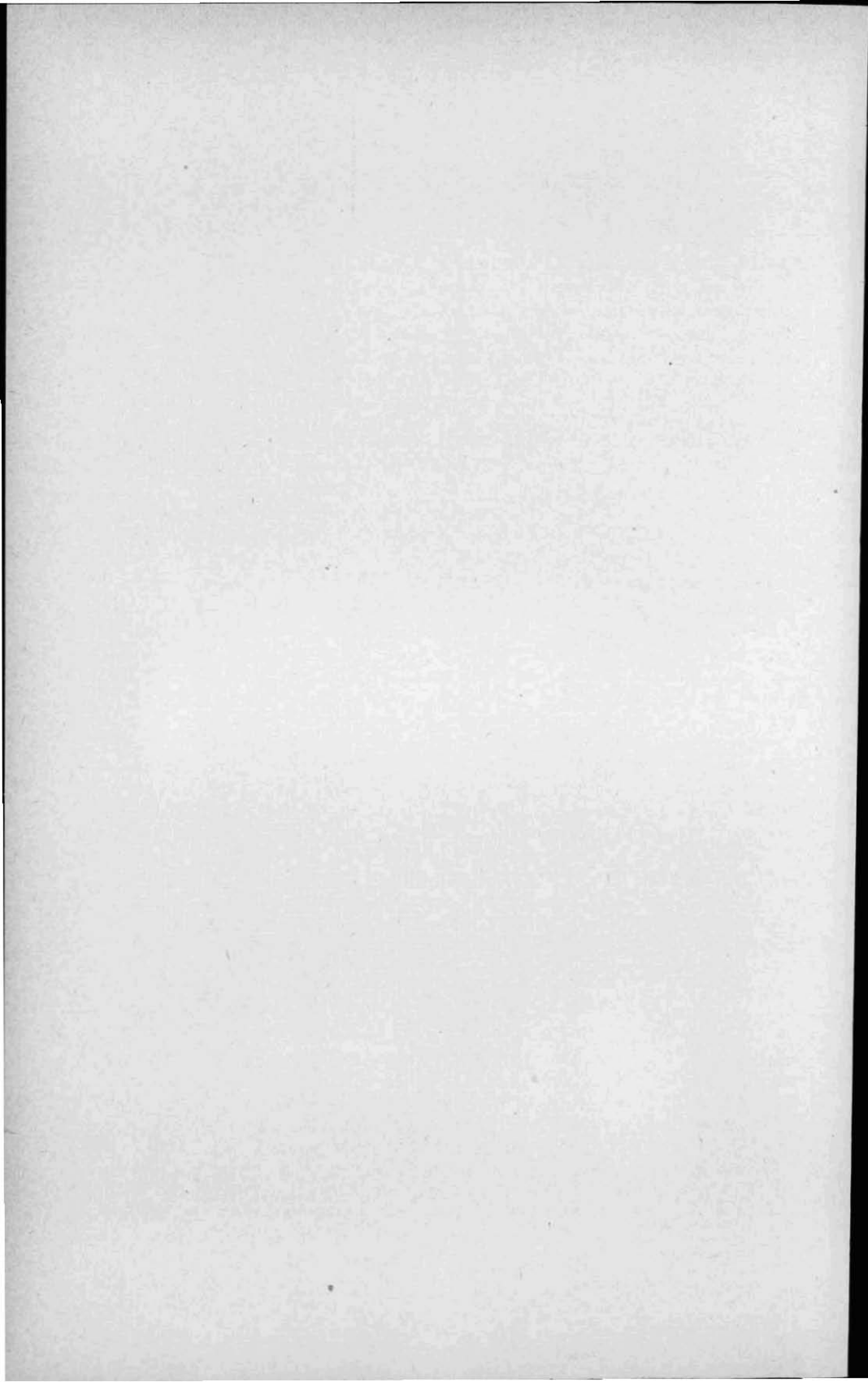
The PHOSPHORUS REQUIREMENT
of EWES
FOR PREGNANCY AND LACTATION

BY

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The Phosphorus Requirement of Ewes for Pregnancy and Lactation

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THE sheep industry is familiar with the significant variation in reproductive output of ewes that result from good and poor nutritional environmental conditions. However, only in recent years has this area (Idaho) been cognizant of the fact that a phosphorus deficiency may occur in sheep where they are grazed on dry range forage and wintered on low phosphorus hay (less than 0.14 percent phosphorus). Many times range ewes are subjected to feed conditions, especially during the late summer and fall months, which are extremely low in phosphorus. Analysis of the range forage grazed by sheep in Idaho by Beeson, Hickman, Bolin and Rinehart (2) has shown that the average phosphorus content of winter forage was 0.084 percent. Ewes remaining on feed this low in phosphorus would deplete their body stores and come into the winter feed lot in a critical state of phosphorus nutrition.

Holm and Bolin (7) have recently reported the occurrence of abortions and weak lambs among range ewes that had been subjected to low phosphorus feeds during the fall and winter months. These ewes were bred to lamb in February and were not fed alfalfa hay until the latter part of December. Ewes bred to lamb on the range during April did not show signs of aphosphorosis because of the longer period of alfalfa hay feeding prior to lambing. A majority of the ewes that aborted showed deficient levels of blood phosphorus. Changing the ration to feeds richer in phosphorus or supplementing the diet with steamed bonemeal prevented the abortions. Beeson, Terrill and Bolin (6) revealed that ewes handled under range conditions exhibited low blood phosphorus levels at certain seasons of the year, but apparently no clinical symptoms occurred because of the short duration of the low phosphorus periods. Lambing, lactation and age tended to decrease the blood phosphorus level even though the ewes received adequate phosphorus and a loss of body weight tended to increase the blood phosphorus level.

Since a review of the literature on the phosphorus requirement of ewes recently was published by Beeson, Hickman and Johnson (1) only the research having a specific bearing on this study will be mentioned. This review indicated wide variations in the amounts of phosphorus required for the ewe and a need for further study under conditions that are more typical of the areas confronted with this problem. Knowledge of the amount of phosphorus necessary for maximum production of lambs and milk by the ewe is an important factor in sheep production. This research was designed to

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furnish fundamental information on this problem and this paper gives a progress report on it. Two previous experiments in this series have been briefly reported by Beeson, Johnson, Bolin, Hickman, and Rinehart (4,5).

Experimental

One hundred sixty-seven head of crossbred white face ewes were bred at random to three purebred Suffolk rams for early shed lambing (February). At the end of breeding season (October 27) the ewes were divided into three groups and were fed from October 25, 1944 to April 23, 1945 on the following daily rations:

Lot I—Dried beet pulp 1.0 pound, free access to approximately equal parts of alfalfa hay and bean straw, and salt.

Lot II—Same as Lot I excepting 1.0 percent of steamed bone-meal was added to the dried beet pulp.

Lot III—Free access to alfalfa hay and salt.

After lambing the ewes in Lots I and II received an additional allowance of 1.0 pound of dried beet pulp and Lot III received 1.0 pound of barley per ewe daily. The daily amounts of feed consumed and percentage of phosphorus in the diet are given in Table 1. The first two rations (Lots I and II) are not typical of usual feeding practices, but it was necessary to deviate from the truly practical in order to compound diets that were low in phosphorus. The phosphorus content of the rations fed expressed in percentage of the total air dry ration was: Lot I 0.4 percent, Lot II 0.16 percent and Lot III 0.19 percent.

The ewes were fed in open lots during the fall and winter, excepting for the short period they were confined to a shed after lambing. The ewes were kept on an irrigated farm at the Branch Agricultural Experiment Station, Caldwell, during the entire year. During the late spring, summer, and early fall the ewes were grazed on aftermath crops and irrigated pastures.

In order to check the condition of the phosphorus metabolism of the ewes, blood samples were taken at the following intervals: beginning of wintering period, latter part of gestation period, 1 to 3 weeks after lambing and 7 to 8 weeks after lambing. Blood samples were collected from the jugular vein of ten ewes from each lot and analyzed for inorganic phosphorus.

Results and Discussion

A complete summary of the data is presented in Table 1.

Effect on Lamb and Ewe Weights

Although the ewes in Lot I showed a definitely deficient level of blood phosphorus (1.94 mg. per 100 ml.) after lambing, there was no noticeable effect on the percent lamb crop or the growth of the lambs. The percentage of lambs raised in the various lots (I, II and III) was respectively 125, 121 and 133, and the average birth weight of the lambs ranged from 10.1 to 10.5 pounds. Apparently there was no significant difference in the milking qualities of the

ewes since the lambs weighed respectively 48, 46, and 47 pounds at approximately 70 days of age. The only outward difference between the three lots of ewes was the occurrence of a larger percentage of thin ewes in the group (Lot I) that was on the lowest phosphorus diet (0.14 percent phosphorus). At the close of the dry lot period the ewes weighed in the group order an average of 108, 111 and 120 pounds. The ewes receiving the low phosphorus diet (Lot I) did not appear as thrifty and fat as the other ewes. This suggests that although the phosphorus deficiency was not reflected in the development of the lambs, the ewes compensated for this inadequate phosphorus intake by depleting their bodies. Miller, Hart and Cole (8) have reported in their studies with breeding ewes that stores of phosphorus are depleted slowly, whereas protein deficiency manifests itself in a shorter time. The length of period required for a phosphorus deficiency to show an effect on the lamb crop is still a matter of conjecture. These ewes were fed on this low phosphorus diet for 177 days and have been on low phosphorus levels for two previous wintering periods. However, for about 6 months of the year the ewes had access to farm pasture and aftermath crops which provides a period for replenishing the body stores with phosphorus.

Ewes handled under range conditions have access to forage that is rich in phosphorus during the spring and summer months, but are usually subjected to dry range forage during the fall and part of the winter months which is low in phosphorus (Beeson et al, (2)). The critical period in the phosphorus nutrition of sheep is during the fall and winter seasons. If a phosphorus supplement such as bonemeal, is needed this is the time to supplement the ration.

Blood Phosphorous Values

The amount of phosphorus in the blood is a good index to whether a ewe is ingesting sufficient phosphorus for normal nutrition. Usually blood phosphorus values of 4.0 mg. or less per 100 ml. of blood plasma are considered below normal and values of 3.5 mg. or less are definitely deficient.

A study of the blood data shows that milk production in the ewe increases the requirement for phosphorus. Three weeks after lambing all the ewes tested in Lot I showed abnormally low blood phosphorus values (range 1.5-3.5 mg/100 ml.) which is indicative of aphosphorosis. The ewes receiving 1.0 percent of bonemeal in the diet, showed higher average values (4.53 mg.) but there were a few ewes that had deficient blood phosphorus levels, (as low as 2.2 mg.). In the alfalfa hay lot (III) all ewes tested were within the normal range but this would be expected since after lambing this lot received 1.0 pound barley per ewe daily which increased the phosphorus intake to 5.03 grams per ewe daily. Lots I and II received an additional pound of dried beet pulp daily, which furnished an additional source of energy but very little phosphorus. A previous study by Beeson, Terrill and Bolin (6) has shown that blood phosphorus values vary with age, period of pregnancy, stage of lac-

Table 1.—The phosphorus requirement of ewes for reproduction and lactation.
Department of Animal Husbandry—Caldwell Branch Station
University of Idaho, Moscow

	Lot I Dried beet pulp Alfalfa hay Bean straw Salt	Lot II Dried beet pulp Alfalfa hay Bean straw Bonemeal Salt	Lot III Alfalfa hay Salt			
Ewe Weights						
Beginning of breeding season, September 2, 1944, lb.	119	120	119			
Beginning of dry-lot period, October 2, 1944, lb.	117	119	119			
Latter part of gestation period, January 5, 1945, lb.	146	142	149			
During lactation period, April 4, 1945, lb.	118	121	130			
End of dry lot period, April 23, 1945, lb.	108	111	120			
Wool Weights						
Av. wool weight per ewe, April 14, 1945	9.54	9.4	10.68			
Lambing Record						
Number of ewes bred, September 2, 1944	51	58	58			
Number of ewes lambed, January 26 to March 15	48	5	56			
Number of lambs dropped (total)	68	74	82			
Number of sets of twins	11	20	26			
Number of lambs raised, April 4, 1945	64	70	77			
Number of lambs lost	4	4	5			
Percentage of lambs raised, April 4, 1945	125	121	133			
Number of dry ewes	3	2	2			
Number of ewes died	2	2	0			
Lamb Weights and Gains						
Average birth weight per lamb, lb.	10.2	15	10.1			
Average weight per lamb, April 4, 1945, lb.	38.0	32	37.5			
Average weight per lamb, April 23, 1945, lb.	48.5	43	47.2			
Average daily gain from birth to April 23, lb.	0.52	0.50	0.51			
Feed Consumption						
Average daily feed per ewe from October 27 to April 23						
Alfalfa hay, lb.	1.53	1.60	3.73			
Bean straw, lb.	1.79	1.85				
Dried beet pulp, lb.	1.00	1.00				
Salt, lb.027	0.026	.028			
Bonemeal, lb.		0.009				
Average daily supplemental feed for ewes during lactation						
Dried beet pulp (1), lb.	1.00	1.00				
Barley, lb.			1.00			
Average daily feed per lamb—creep fed (2)						
Oats	0.22	0.19	0.21			
Alfalfa hay (long, 3rd cutting)	0.27	0.26	0.29			
Phosphorus In Diet						
Phosphorus in ewe ration prior to lambing—percent	0.14	0.16	0.19			
Phosphorus in ewe ration after lambing—percent	0.13	0.16	0.23			
Daily phosphorus intake per ewe prior to lambing, gm.	2.71	2.21	3.26			
Daily phosphorus intake per ewe after lambing, gm.	3.09	2.98	5.03			
Daily phosphorus intake per 100 lb. of ewe weight prior to lambing, gm.	2.11	1.47	2.43			
Daily phosphorus intake per 100 lb. of ewe weight after lambing, gm.	2.49	2.18	3.78			
Blood Phosphorus Values(3) (mg. per 100 ml. of blood plasma)						
	Av.	Range	Av.	Range	Av.	Range
Beginning wintering period	4.84	3.9-5.9	4.82	3.3-5.9	5.02	4.3-5.5
Latter part of gestation period	5.61	4.5-9.2	5.33	3.2-6.7	4.16	3.2-4.7
One week after lambing	4.45	4.0-4.8	5.35	4.0-6.1	4.70	3.6-5.5
Three weeks after lambing	2.18	1.5-3.5	4.53	2.2-8.2	6.93	6.8-7.0
Seven to eight weeks after lambing	1.94	1.3-2.7	2.74	1.8-4.6	4.82	3.7-7.0

tation, loss of body weight, and number of lambs per ewe. This may give a partial explanation for the low values for the ewes receiving bonemeal.

Phosphorous Requirement for Pregnant Ewes

The general conclusion indicated by the findings of this study is that a level of 0.14 percent of phosphorus in the diet of ewes is on the border line for maintaining a normal phosphorus balance in ewes during pregnancy and is not reflected in the lamb crop. This conclusion is supported by the extremely low blood phosphorus values and the thin and emaciated condition of the ewes. Expressed in other terms, an intake of 2.11 grams of phosphorus daily per 100 pounds of ewe weight is not sufficient amount for normal phosphorus metabolism.

These data indicate that a ewe receiving a ration containing 0.16 to 0.19 percent phosphorus on an air dry basis is adequate for ewes during the gestation period. This amount of phosphorus in the diet allows a daily intake of 3.21 to 3.26 grams daily per ewe or 2.47 to 2.43 grams per 100 pounds of live weight.

These data are substantiated by similar results obtained by Beeson, et al. (5) using the same group of ewes in 1943-44. The ewes were divided equally into three lots and fed during the gestation period as follows: Lot I alfalfa hay and salt (0.16 percent phosphorus); Lot II alfalfa hay, salt and bonemeal (0.18 percent phosphorus); and Lot III high phosphorus alfalfa hay and salt (0.22 percent phosphorus). From these diets the ewes ingested respectively 3.02, 3.69, and 4.02 grams of phosphorus daily or on the basis of per hundred pounds of live weight 2.52, 3.10, and 3.37 grams of phosphorus. There was no significant difference between the groups in regard to number of lambs produced, weight of lambs, milking qualities of ewes or weight of ewes. These data suggest

(1) A total of 2.0 pounds of dried beet pulp was fed per ewe after lambing in Lots I and II.

(2) The lambs also had access to the feed fed to the ewes.

(3) Any blood phosphorus value below 4.0 mg. per 100 ml. is indicative of a subnormal level.

Phosphorus content of feeds used	percent
Alfalfa hay, first cutting	0.17
Alfalfa hay, second cutting	0.22
Alfalfa hay, third cutting	0.17
Lima bean straw	0.14
Dried beet pulp	0.07
Barley	0.39
Oats	0.37
Steamed bonemeal	13.80

that a ration containing 0.16 percent phosphorus resulting in a daily intake of 2.52 grams of phosphorus per 100 pounds of live weight is adequate during gestation. Apparently the phosphorus requirement for pregnant ewes is very similar to the requirement for fattening lambs (Beeson, et al. (3)).

Phosphorous Requirement for Lactation

In this experiment the ewes in Lots I and II were fed an additional pound of dried beet pulp per ewe daily after lambing. This gave each ewe a daily intake of 2.0 pounds of dried beet pulp. The addition of dried beet pulp increased the energy intake of the ewes but did not increase the percentage of phosphorus fed. The ewes in Lot III were fed on a pound of barley per ewe daily after lambing, and since barley is a good source of phosphorus this increased the amount in the diet from 0.19 to 0.23 percent, or an increased daily intake of 1.77 grams. In other words the usual practice of adding a pound or more of grain to the diet of a ewe after lambing serves not only as an emergency food but also as a phosphorus supplement, especially when ewes are on a borderline intake during pregnancy.

The ewes receiving 0.13 percent of phosphorus in the ration after lambing were abnormally low in blood phosphorus, declining from an average value of 4.45 mg. for one week of lactation to 1.94 mg. for 7 to 8 weeks after lambing. This shows that the ingestion of 3.09 grams phosphorus per ewe daily or an intake of 2.49 grams per 100 pounds of live weight is inadequate for ewes suckling lambs. The addition of 1.0 percent of bonemeal to the dried pulp (Lot II) increased the percentage of phosphorus to 0.16 and the daily intake per hundred weight to 3.18 grams. This amount proved to be only partially adequate for the blood phosphorus values ranged from 4.6 mg. down to 1.8 mg.

A level of 0.16 percent phosphorus on an air dry basis is not adequate for lactation but should be classified on the borderline level. The phosphorus requirement for lactation was met (Lot III) by feeding a diet containing 0.23 percent phosphorus with an intake of 3.78 grams per hundred weight.

The two previous experiments in this series by Beeson, et al., (4,5) have given similar results, showing the lactation demands of ewes were satisfied by an intake ranging from 3.50 to 4.31 grams per hundred weight, when the diet was made up of barley 1.0 pound, and free access to alfalfa hay and salt. The alfalfa hay fed ranged in phosphorus values from 0.16 to 0.22 percent and the total air dry phosphorus content of the ration from 0.19 to 0.23 percent. Lactating ewes maintained on rations containing 0.14 percent phosphorus with an intake of 1.89 grams per hundred pounds of ewe weight showed definite signs of aphosphorosis.

Other Nutritional Deficiencies Associated With Aphosphorosis

Many times a phosphorus deficiency is associated and complicated with other nutritional deficiencies. Miller, Hart and Cole (8) have shown that in an average ration protein and phosphorus are

closely associated and low protein is usually accompanied by low phosphorus. This is most clearly brought out by briefly reviewing the results of the first experiment in this series by Beeson, Johnson, Hickman, Bolin and Rinehart (4). In 1942-1943, 65 bred ewes were wintered during the entire gestation period on a ration containing 0.11 percent phosphorus consisting of alfalfa chaff, clover chaff and salt. This allowed a daily intake of 1.50 grams of phosphorus per 100 pounds ewe weight. The ewes in this group were definitely deficient in phosphorus. A similar group of ewes received the same basal ration with free access to bonemeal. This raised the phosphorus intake to 2.40 grams per hundred weight and resulted in an adequate phosphorus level. The response to bonemeal feeding was not as favorable as expected due to the fact that a low protein intake and possibly a lack of other nutritional factors tended to mask the results. The third group of ewes fed on alfalfa hay (0.20 percent phosphorus) and salt were normal in every respect in regard to lamb and milk production. The latter diet is typical of the way most range ewes are fed during the wintering period and it is interesting to note that their daily intake of phosphorus was 3.16 grams per 100 pounds of live weight. During lactation the addition of 1 pound of barley per ewe daily increased the phosphorus in the air dry ration to 0.21 percent.

Under natural conditions on dry range forage a phosphorus deficiency may be accompanied by a protein deficiency, which makes it advisable to supplement the range forage with some high protein concentrate feed such as cottonseed, linseed, or soybean cake. Cottonseed, linseed, and soybean cake contain respectively 1.19, 0.86 and 0.66 percent phosphorus or each pound would supply 5.40, 3.90 and 3.00 grams of phosphorus. Protein concentrates are excellent phosphorus supplements.

Summary

1. Three experiments to determine the phosphorus requirement for ewes during pregnancy and lactation have been carried out using crossbred white face ewes. This paper reports the third experiment in this series in detail along with a review of the important points in the two previous trials.

2. The findings of this study show that a level of 0.14 percent or less phosphorus (air dry basis) in the diet of ewes is on the borderline for adequately maintaining a normal phosphorus balance during pregnancy and is definitely inadequate for lactation.

3. Ewes fed on rations containing 0.16 to 0.19 percent phosphorus on an air dry basis received adequate amounts of phosphorus for the gestation period. This amount of phosphorus allows a daily intake of 3.21 to 3.26 grams daily per ewe or 2.47 to 2.43 grams per 100 pounds of liveweight. In practical terms a ewe receiving 3.5 to 4.0 pounds of good quality alfalfa hay (0.19 to 0.22 percent phosphorus) daily would be amply supplied with phosphorus. In round figures a pound of good quality alfalfa hay contains about 1.0 gram

of phosphorus. On this basis the phosphorus needs of a ewe can be met by feeding 2.5 pounds or more of high quality alfalfa hay daily per 100 pounds of ewe weight.

4. Ewes suckling lambs have an appreciably higher phosphorus requirement than during the gestation period. This research shows that the phosphorus requirement of a lactating ewe may be met by feeding rations containing 0.23 percent phosphorus or more, which provides a daily consumption of 3.78 grams per hundred weight. A level of 0.13 percent phosphorus in the diet was too low to maintain normal blood phosphorus values during lactation and 0.16 percent level was on the borderline of being adequate.

5. In general these data show that adequate phosphorus is supplied if ewes are wintered part of the gestation period on range forage or roughage containing 0.16 percent or more phosphorus and then wintered for the remainder of the time on good quality alfalfa hay plus salt until lambing. After lambing the addition of 1.0 pound or more of grain to the alfalfa hay-salt diet will supply sufficient phosphorus. If the phosphorus needs are not met with the use of range and farm grown feeds, then the ewes should be given free access to a mixture of equal parts of steamed bonemeal and salt during the gestation and lactation period.

6. Sometimes low phosphorus and low protein conditions occur simultaneously in the feeding regimen of breeding ewes. These deficiencies may be corrected by supplementing the ewe ration with some suitable protein concentrate, such as cottonseed, linseed cake, or soybean cake.

Literature Cited

1. **Beeson, W. M., C. W. Hickman and R. F. Johnson**, 1944. Calcium and phosphorus for breeding ewes. *Flour and Feed*, 1945. Vol. 46, No. 4, pp. 12-13.
2. **Beeson, W. M., C. W. Hickman, D. W. Bolin and E. F. Rinehart**, 1939. Fall and winter range plants found to be low in phosphorus. 47th Annual Report, Idaho Agr. Exp. Sta. Bul. 236, pp. 8-9.
3. **Beeson, W. M., R. F. Johnson, D. W. Bolin and C. W. Hickman**, 1944. The phosphorus requirement for fattening lambs. *Jour. of Animal Sci.* 3: 63-70.
4. **Beeson, W. M., R. F. Johnson, D. W. Bolin, C. W. Hickman, and E. F. Rinehart**, 1944. Low phosphorus diet affects milking qualities of ewes. 51st Annual Report, Idaho Agr. Exp. Sta. Bul. 255, pp. 5-6.
5. **Beeson, W. M., R. F. Johnson, D. W. Bolin, C. W. Hickman and E. F. Rinehart**, 1945. How much phosphorus does a ewe need? 52nd Annual Report, Idaho Agr. Exp. Sta. Bul. 264, pp. 5-6.
6. **Beeson, W. M., C. E. Terrill, and D. W. Bolin**, 1944. Some factors affecting the blood phosphorus level of range ewes. *Jour. of Animal Sci.* 3: 175-182.
7. **Holm, G. C., and D. W. Bolin**, 1944. Range ewe abortions. *Idaho Wool Growers Bulletin*, Vol. 23, No. 13, p. 2.
8. **Miller, R. F., G. H. Hart, and H. H. Cole**, 1942. Fertility in sheep as affected by nutrition during the breeding season and pregnancy. *California Exp. Sta. Bul.* 672.

