A STUDY OF SYSTEMS OF MANAGEMENT AND PROTEIN SUPPLEMENTS FOR RANGE HEREFORD COWS AND THE EFFECT OF EACH UPON CERTAIN BLOOD CONSTITUENTS OF THE COWS AND THEIR CALVES

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INTRODUCTION

Extensive investigations have shown the importance of proper nutrition of animals during reproduction and lactation. Classical experiments have demonstrated that failure to provide an adequate dietary to the pregnant and lactating female has resulted in reproductive failures, abnormal or weak young and decreased rates of growth of the offspring.

Many investigations have been reported concerning the nutritive requirements of the bovine not only for growth but also for reproduction and lactation. The most extensive studies have been those concerning cattle of dairy breeding. The high production of the dairy cow and the intensive systems of management of the dairy farmer have required that he be more cognizant of nutritional needs than the beef cattle producer. This has not meant that nutritional problems of beef cattle are not important but that investigators were aware at an earlier date of the need for the study of the nutritional requirements of the milk producing "machine", the dairy cow.

As the dietary need of the dairy cow was explored and information accumulated, it offered some explanation for the problems of the beef cattle producer. At the outset it was quite apparent that the nutritional requirement of the beef cow was not materially different from that of the dairy cow qualitatively but that under some conditions the quantative requirement varied. The systems of management employed by the beef cattle producer differ considerably from those employed for the high producing dairy cow and have contributed in part to the fewer nutritional problems generally encountered by the beef cattle producer.

Many systems of management are employed by the beef cattle man. The investigation reported herein was designed to study two systems of management of a commercial cow herd adaptable to Oklahoma. In addition, nutritional studies involving two protein supplements are presented together with fundamental information concerning certain blood constituents of Hereford cows and the blood of their calves.

REVIEW OF LITERATURE

The systems of beef production in this and many other countries have undergone profound changes during the past score of years. These changes have made it mandatory that the beef producer have a thorough knowledge of the nutrient requirements of his cattle.

Hart and Guilbert (1928) found that beef cows must put on weight in the late fall and early winter in order to be at "normal weight" by calving time in the spring.

Lantow (1933) found that for wintering beef cattle one pound of cottonseed cake per head per day was more profitable than 2, 3 or 4 pounds and that the heavier feeding of cottonseed cake resulted in slower gains during the summer.

Black, et al. (1938), studying beef cows wintered with and without a supplement of cottonseed cake, found that weight losses of cows that received no supplement were significantly greater than weight losses of cows that received the supplement. However, the increased weight of calves at weaning time, from the supplement fed cows did not compensate for the increased wintering feed costs.

Taylor (1942) found that 43 percent cottonseed cake was slightly more economical for wintering range cows on dry grass pasture than 41 percent soybean pellets.

Black, et al. (1943) stated that ranchmen have the object in view to winter their breeding cows with a minimum outlay of feed and labor and still obtain a normal number of good calves.

Guilbert (1944) stated that any consideration of efficiency of beef production must begin with the cow herd, the percentage of calf crop, and the weaning weight of the calves.

Morrison (1946) has summarized much of the published work relative to the nutritive requirements of beef cattle and in addition presented some of the general factors that influence beef production. He stated that alfalfa hay has no superior with respect to other roughages for beef cattle. He further stated that when even a reasonable part of the roughage consists of well cured alfalfa hay, there will be no deficiency in the quality of protein nor in the calcium and vitamin A in the ration.

Snapp (1946) as well as several other authors in the Yearbook of Agriculture (1942) have summarized a great deal of the work relative to systems of management, disease control and prevention and many other nutritional aspects of beef cattle production.

Ross, et al. (1947) reported a four year study of two systems of cow herd management. They found that grazing cows year long and supplementing the cured grass with cottonseed cake was more economical than grazing cows during the summer and feeding them prairie hay and cottonseed cake during the winter in a trap. They reported that there was no difference in the condition of the cows at the end of the experiment or in the size of the calves at weaning.

Carotene and Vitamin A

The indispensable nature of vitamin A for the dairy calf was shown by Jones, Eckels, and Palmer (1926).

Baumann, et al. (1934) studied the influence of breed and diet of cows on the carotene and vitamin A content of butter. They found that 3.3 percent of the vitamin A ingested by cows fed a low carotene ration was secreted in the milk and for those fed a high carotene level, only 1.3 percent was secreted in the milk. Semb and others (1934) found that 8 percent of the plasma carotene was secreted in the milk daily.

Guilbert and co-workers (1934) found that calves from heifers fed a restricted intake of vitamin A developed diarrhea at two to eight days of age.

The milk of the dams of these calves was found to be subnormal in its vitamin A content. No clinical symptoms were evident in the cows up to six months after parturition, but night blindness occurred in one of the calves.

Guilbert and Hart (1935) found the minimum daily carotene requirement for the bovine to be 26 to 33 mcg. per kg. of live weight, and they hypothesized that the vitamin A requirement was related to the body weight of the animal and not to the net energy requirement. They also stated that evidently the fetus was the first to suffer from a borderline carotene deficiency.

Converse and Meigs (1936) concluded that the vitamin A supplied by whole milk in rations for dairy calves was more valuable than the fat or energy supplied.

Guilbert, _et al._ (1936) showed that the minimum carotene requirement for all the species of farm animals that they studied was 25 to 30 mcg. per day per kilogram of body weight. The minimum vitamin A requirements were found to be 6 to 8 mcg. per day per kilogram of body weight.

Jones and Haag (1938), studying growth and reproduction in dairy heifers, obtained results which indicated that a comparatively low vitamin A ration resulted in serious disturbance to heifers when fed over a period of about six months, either preceded or followed by a pasture period.

Ward, _et al._ (1938) studying the carotene requirement of the dairy calf using varied rations, found that 12 to 14 mcg. per pound of body weight per day was sufficient to prevent vitamin A deficiency symptoms. They also found that dairy heifers fed a carotene deficient ration during the winter months showed no deficiency symptoms if they had been on good pasture during the summer months.

That calves need protective vitamin A during the first three to four months of life has been shown by Converse and Meigs (1939). They found that calves need amounts of carotene and vitamin A much larger than that of normal cattle from six months to two years of age. Moore (1939), studying calves maintained on low carotene rations until 40 to 90 days of age, found that the calves developed nyctalopia in from 48 to 73 days. Papillary edema also developed in about the same period of time in these calves. An intake of 9 mcg. of carotene per pound of body weight was not sufficient to prevent nyctalopia or decrease papillary edema. An intake of 16 mcg. per pound of body weight was sufficient to maintain the plasma carotene at 0.2 mcg. per ml. and above in Holstein and Ayrshire calves. This intake was sufficient to prevent nyctalopia and maintain fair general health in the calves.

Guilbert, et al. (1940) reported that cows on a minimum vitamin A ration were able to produce live young, but that the calves were weak and soon died. Vitamin A supplementation at three to four times minimum levels beginning the last month of pregnancy resulted in normal calves and the mothers supplied sufficient vitamin A in their milk for normal growth of the calves for at least three months following parturition.

Henry and others (1940) studying nine Shorthorn heifers that had access to good pasture before calving, found no increase in the secretion of vitamin A in the colostrum, but an increase in the output of carotene was noted. Riggs (1940) stated that the accumulation of vitamin A in the body increased with age and was dependent on the character of the diet.

Kuhlman and Gallup (1940, 1941) reported that an average daily intake of from 40 to 45 mcg. daily per pound of body weight was about the minimum amount of carotene which would meet the requirements of Jersey cows for normal calving. Factors such as the health of the calf as well as the ability of the cow to begin normal lactation were taken into consideration.

Davis and Madsen (1941), studying cattle on restricted levels of carotene intake, found that the carotene and vitamin A content of blood plasma was dependent on the carotene intake and previous storage of these factors.

Gallup and Kuhlman (1941) in an experiment with Jersey cows, found that plasma carotene values usually dropped immediately or soon after parturition and that there was no consistent change in these values during the first few weeks after parturition.

Moore (1941) found that mature dairy cows fed a vitamin A deficient ration failed to develop blindness due to constriction of the optic nerve such as has been reported in calves, but when the plasma carotene values were as low as 0.2 to 0.5 mcg. per ml. of blood, deficiency symptoms usually followed in a short time.

Boyer, et al. (1942) found that 10 or more mcg. of vitamin A per 100 ml. of plasma was necessary for adequate vitamin A nutrition of the growing dairy calf.

Kenner, et al. (1942) found the minimum carotene requirement of dairy calves maintained in an environment with the temperature ranging from 50 to 70 degrees Farenheit, to be approximately 12 mcg. per pound of body weight per day. Respiratory and bowel disturbances were more prevalent during periods of low blood vitamin A than when the level of plasma vitamin A was considerably higher.

Stewart and McCollum (1942) studying the effect of vitamin A enriched diets on the vitamin A content of the colostrum of dairy cows, failed to find a difference in the milk of control cows as compared to those fed the vitamin A rich concentrate.

Sutton and Soldner (1943), working with dairy cattle, reported that blood carotene and vitamin A levels remained at about constant levels up to about a week before calving. Just prior to calving, a decline in both plasma carotene and vitamin A were found to occur and a further drop was observed immediately after parturition. Kuhlman and Gallup (1944), studying carotene blood plasma levels of Jersey cows at parturition, reported changes similar to those found by Sutton and Soldner (1943).

Braun (1945), studying carotenoid and vitamin A levels in the blood of cattle, found a linear increase of plasma vitamin A as the carotenoid level increased. "The ratio of plasma vitamin A to plasma carotene at various carotene levels was found to decrease with increasing carotenoid levels".

A recent report of the committee of Animal Nutrition of the National Research Council (1945) stated that 1.4 to 1.6 mg. of carotene per 100 lbs. live weight per day proved adequate for normal growth of beef cattle. At this intake, however, there was little or no storage to meet the exigencies of life. The recommended allowance for beef cattle was 5.5 mg. per 100 lbs. live weight per day. The minimum requirements of vitamin A for growth was established as 1000 I. U. daily for each 100 lbs. of live weight. For suckling calves, 6000 to 9000 I. U. were considered sufficient when milk was the sole source of this nutrient.

Lewis and Wilson (1945), in an experiment with dairy calves, obtained results which indicated that 32 U.S.P. units of vitamin A per kilogram of body weight was the minimum requirement for growth. The level required for optimum growth was found to be 64 U.S.P. units of vitamin A per kilogram of body weight. When both growth and liver storage were taken into consideration, the daily intake of vitamin A for young calves was found to be about 250 U.S.P. units per kilogram of body weight.

Moore and Berry (1945), studying calves of the Holstein, Ayrshire, and Guernsey breeds from birth up to four months of age, found that the vitamin A content of the blood plasma varied from 7.2 to 14.0 mcg. per 100 ml.

Sutton and Soldner (1945), studying seasonal plasma carotene and vitamin A variations in the blood plasma of adult dairy cattle, found that the average monthly range of plasma vitamin A for all dairy breeds investigated ranged from 18 mcg. per 100 ml. of plasma in June, to 24 mcg. per 100 ml. of blood plasma in October.

Sutton, Warner, and Soldner (1945) found that the maximum decrease in blood plasma carotene of lactating cows occurred one week following parturition.

The maximum decrease in blood plasma vitamin A was reached three days after parturition.

Hansen, et al. (1946) found that the vitamin A of colostrum from barn fed dairy heifers in the first lactation was more than twice the vitamin A content of the colostrum from the same cows in the second lactation. Seven-fold variation in the colostral vitamin A potency occurred in these cows. The cows were fed identical rations and maintained under uniform conditions during two lactating periods. An increase in the blood plasma vitamin A concentration of the newborn calf was observed following the ingestion of colostrum and the percentage increase tended to reflect the concentration of vitamin A present in the colostrum of their dams.

Hibbs and Krauss (1946) reported that regardless of the amount of vitamin A fed to dairy calves, the blood level seldom exceeded 25 mcg. per 100 ml. and that the decrease of blood vitamin A during the first few weeks after birth could largely be offset by feeding additional vitamin A.

Kaeser and Sutton (1946), studied the utilization of colostrum in calf feeding. They found that calves that received extra amounts of colostrum maintained higher levels of plasma vitamin A and carotene during the first four weeks after birth than those fed the lower amounts of colostrum. The calves also gained more rapidly and were superior in appearance at four weeks of age when fed extra colostrum.

Payne and Kingman (1946) reported that in order to support normal gestation, the carotene blood plasma level of first calf Hereford heifers must be considerably higher than that for aged Hereford cows. They also reported that at least 117 $\pm$ 7.21 mcg. per 100 ml. of blood plasma was necessary to support normal gestation in heifers. When a carotene level of 97.18 $\pm$ 7.68 mcg. per 100 ml. was found in range Hereford heifers retained placenta and nutritional abortion were observed. Aged Hereford cows with carotene blood levels as low as 82.88 $\pm$

4.11 mcg. per 100 ml. showed no symptoms over a two year period which could be attributed to carotene or vitamin A deficiency.

Spielman, et al. (1946) studying carotene utilization by the newborn dairy calf, found that intestinal infection and scours resulted in reduced absorption and utilization of carotene.

Thomas, Spielman, and Turk (1946) showed that the concentration and total output of vitamin A and carotene in cows' colostrum was influenced by the ration fed during the two months immediately prior to parturition.

Frey and co-workers (1947) found that dietary vitamin A did not definitely increase the hepatic stores of carotene in Hereford steers. They concluded that the serum levels and the hepatic stores of vitamin A appeared to be controlled by different body mechanisms.

Glover and co-workers (1947) also found that rats, when given large doses of beta-carotene, converted a certain amount of it to vitamin A in the intestines. More than twenty international units of vitamin A were found in each of the three intestines of rats six hours after dosing with 5 to 15 mg. of beta-carotene. A very good summary of the site of conversion of carotene to vitamin A in the rat was published in the March issue of Nutrition Reviews (1948).

Lemly, et al. (1947) found that the storage of vitamin A in the liver of the rat was in proportion to the intake of vitamin A. Glover, Goodwin, and Morton (1947) found that the plasma vitamin A level of rats was proportional to the concentration of the vitamin A alcohol in the liver, but was not proportional to the total liver storage of vitamin A which consisted mainly of vitamin A esters. They found that plasma vitamin A levels were maintained near normal (35-40 mcg./100 ml.) even when liver storage approached exhaustion.

Maynard (1947) summarized the requirements, physiological functions, and deficiency symptoms of vitamin A.

Parrish and co-workers (1947) found that practically all of the vitamin

A in both colostrum and milk was in the form of the vitamin A ester. Most of the fat soluble yellow pigment in colostrum and milk was found to be carotene.

Sutton, Warner, and Kaeser (1947) found a rapid decline of carotene and vitamin A in colostrum and milk with each successive milking. Colostrum was approximately ten times as potent in carotene and six times as potent in vitamin A as normal milk. Levels closely approaching normal milk were reached at the end of the third day.

Wise and Atkeson (1947) found that vitamin A intake of the cow had no effect on total milk and fat production. High vitamin A intake increased the concentration of vitamin A in the milk fat, but tended to suppress the carotenoid content. Cows fed high vitamin A rations showed the same characteristic decline of plasma vitamin A at parturition as did non-supplemented cows but those receiving the additional vitamin A maintained higher levels at parturition than did the non-supplemented cows.

Ross, et al. (1948) studying Holstein heifers, found a blood plasma vitamin A level of from 6 to 8 mcg. per 100 ml. blood plasma to be the critical level for maintenance when gain in body weight was used as a criterion of measurement.

Wise, et al. (1948) reporting on postnatal changes in the concentration of carotenoids and vitamin A in the blood serum of calves of their dairy herd, found that "there was a marked degree of variability in the concentrations of carotenoids and of vitamin A in the blood serum of individuals of the group, but that the general trends in the levels of these constituents in each calf were similar". They concluded that the diet seemed to be the primary factor in determining the level of vitamin A and the carotenoids in the blood serum and that under their managerial practices vitamin A supplementation from the colostrum period to the hay period was needed.

Calcium and Phosphorus

Eckles, *et al.* (1926) found a marked inhibitation of oestrum in cows fed phosphorus deficient feeds. Cows in milk showed the most severe symptoms.

Eckles and Gullickson (1927) found that a phosphorus deficiency did not affect the digestibility of the ration but did affect the utilization of the nutrients after they had been digested.

The concentration of inorganic phosphates in the blood plasma of cattle as an aid in clinical diagnosis of a phosphorus deficiency even before physical symptoms became apparent was first reported by Palmer and Eckles (1927), and the South African workers (1927, 1928).

Thieler, *et al.* (1927) reported that the phosphorus content of the blood of cattle receiving adequate phosphorus varied from 4 to 9 mg. per 100 ml. of whole blood with an average value of 5.2 mg.

Green and Macaskill (1928) reported that the total inorganic plasma phosphorus of the blood of a newborn calf may be over twice that of its mother. For the first few days after birth, there was a tendency for the plasma phosphorus to increase. The level then decreased steadily and at ten weeks of age the difference between cow and calf was in some instances only 15 percent.

Theiler, Green and DuToit (1929) studied cattle grazing a phosphorus deficient pasture. They found that mineral supplemented cows showed increased fertility, superior development of calves, and reduced mortality as compared to supplemented cows.

Anderson, Gayley, and Pratt (1930), studying the chemical composition of bovine blood, found that the average,maximum and minimum level of inorganic plasma phosphorus for all animals studied was 4.46, 6.17, and 3.09 mg. per 100 ml. of plasma, respectively. The average for animals less than one month of age was 5.06 mg. per 100 ml. of plasma; for animals one to five months of age, 5.54 mg. per 100 ml. of plasma; for animals six to ten months of age, 4.48 mg. per 100 ml. of plasma; and for animals one to nine years of age, 3.62 mg. per 100 ml. of plasma.

Palmer, et al. (1930), studying dairy cattle blood phosphorus variations, reported that a marked decrease in the inorganic phosphorus content of cows' blood occurred at or near the time of parturition. Most research workers agree that lactating cows and growing animals are most severely affected by a deficiency of available phosphorus in the ration.

Haag, Jones, and Brandt (1932) indicated that a calcium-phosphorus ratio of 10.5 to 1 was no more detrimental than one of 7.6 to 1 for dairy cattle.

Huffman and others (1933) state that blood plasma phosphorus values lower than 4.0 mg. percent should be watched carefully, especially if the animal is less than one year of age. Greaves, Maynard, and Reeder (1934) gave 5.0 mg. percent as the borderline value.

Huffman and co-workers (1933) found that the phosphorus requirement for milk production over and above that required for maintenance ranged from 0.5 to 0.7 grams of food phosphorus per pound of milk.

Greaves, et al. (1934) studying the influence of calcium and phosphorus intake upon bovine blood, found that phosphorus supplementation produced little if any effect on the blood calcium. Inorganic phosphorus in forty steers varied from 2.41 to 3.01 mg. per 100 ml. of plasma.

Fairbanks (1939) stated that the calcium-phosphorus ratio was of greatest importance when the vitamin D of the ration was inadequate.

Knox, Brenner, and Watkins (1941) found that cows with blood plasma levels of 2.0 to 3.0 mg. percent in the winter and spring, and from 3.0 to 4.5 mg. percent in the summer were in excellent health.

Black and associates (1942) found that symptoms of a phosphorus deficiency developed in cattle grazing a phosphorus deficient range when the blood phosphorus content was below 4.0 mg. per 100 ml. of whole blood. Bohstedt (1942) found that calves may tolerate a rather large proportion of calcium to phosphorus.

Black, et al. (1943) found that the phosphorus content of the forage increased during those months following heaviest precipitation.

Black and associates (1943) found that the feeding of 6.5 grams of phosphorus per cow per day to dry cows proved highly beneficial in southern Texas. For the two year period covered by this study, the control cows weaned a 58 percent calf crop whereas the supplement fed cows weaned an 81 percent calf crop. The difference in weaning weight per calf was 6 percent in favor of the supplemented group.

A report of the committee on Animal Nutrition of the National Research Council (1945) advised that cattle should be allowed free access to a phosphorus-rich mineral mixture if the forage should fall below 0.15 percent phosphorus on a dry-matter basis. This committee recommended a range of from 12 grams of phosphorus per head daily for wintering weanling calves, to 24 grams for cows nursing calves.

With many of our farm animals, the supply of phosphorus comes entirely from pasturage and hay which is often low in this element. Mitchell (1947) stated that if the content of pasturage or hay on a dry matter basis is 0.12 percent or less, the roughage will not provide adequate phosphorus for the animal.

Tash and Jones (1947) found that the shorter grasses have a higher average phosphorus content than the taller grasses in the same pasture, if they are at approximately the same stage of development. They also found that palatable weeds contain more of this element than do grasses on the same soil.

Ascorbic Acid

Sheahan (1937) made determinations for ascorbic acid on the blood of 250 cows ranging in age from 3 to 7 years. He found the plasma values to range from 140 to 920 mcg. per 100 ml. of blood plasma. He obtained an average value of 380 mcg. per 100 ml. of plasma.

Phillips and others (1941), studied the relationship of dietary ascorbic acid to reproduction in the cow. They found that there was a low synthesis of vitamin C by vitamin A deficient cows.

Boyer and co-workers (1942) found that the level of plasma vitamin C in dairy calves was contingent upon the level of vitamin A, particularly so when the vitamin A values fell below 0.10 mcg. per ml. of blood plasma. They found that the increased intracranial pressure of a calf suffering from vitamin A deficiency was paralleled by a marked decrease in the ascorbic acid content of the cerebrospinal fluid. "The vitamin A content of the cerebrospinal fluid of the cow is normally five to ten times that of the blood plasma", according to the authors. The administration of vitamin C to vitamin A deficient calves was accompanied by a rise in vitamin C content of the cerebrospinal fluid. A reduction of the cerebrospinal fluid pressure occurred in three out of five cases following the administration of vitamin C. It appeared that vitamin C was in some way associated with the increased intracranial pressure.

Lundquist and Phillips (1945) observed that two grams per day of succinge sulfothiozole was responsible for higher than normal levels of blood plasma ascorbic acid in newborn calves. There was no effect on eight to nine month old heifers.

Moore (1946) found that vitamin A deficient calves showed increased spinal fluid pressure accompanied by decreased ascorbic acid values in the blood and spinal fluid. He concluded that the disturbance in ascorbic acid synthesis in the vitamin A deficient calf plays no part in the mechanism of increased spinal fluid pressure.

Grummer, Whitehair, Bohstedt, and Phillips (1948) working with swine, found that pigs were born with a relatively high plasma vitamin C level (0.98 mg. per 100 c.c.) as compared to that of calves and lambs. The vitamin C level increased rapidly after birth. There was a much sharper rise in the vitamin C level than in vitamin A level. There was a decline in the vitamin C level after the first week of age, and the values continued to decline until the sixth week after birth.

Moore and Cotter (1948) concluded that "it remains to be shown that a low carotene intake under practical farm conditions has a depressing effect on the ascorbic acid synthesis to the extent of altering breeding efficiency."

EXPERIMENTAL

Objectives:

1. To test two systems of management, one a system of grazing year-long and the other, grazing for a part of the year and feeding prairie hay during the winter months.
2. To determine the value of alfalfa hay as compared to cottonseed cake when fed as a protein supplement during the winter months.
3. To study the effect of the systems of management and winter supplements fed upon certain blood constituents of the blood of cows and calves.

EXPERIMENT I

Experimental Procedure:

Forty grade Hereford cows were divided equally into two lots of 20 cows each. The average age of these cows was 4 years. A third lot containing 12 cows averaging 9 years of age was likewise included in Experiment I. All cows had been pasture bred and upon examination were thought to be safe in calf. The cows were started on the experimental rations November 20, 1946, at the Lake Carl Blackwell experimental range. This range is located approximately 13 miles west of Stillwater, Oklahoma on the north side of Lake Carl Blackwell. The cows of Lots 1 and 3 were placed in pastures providing about 12.25 acres of native grass pasture per cow. Of this acreage approximately 2.25 acres had been cultivated for many years but about 1936 was taken out of cultivation and allowed to go back to grass. At the time this experiment was started very little of the better species of grass could be found on these areas previously cultivated. The cows remained in these pastures during the entire year. Salt and a mineral mixture were available at all times. During the winter months (November 20, 1946, to April 7, 1947) each lot was fed the protein supplement shown in Table I. The cows of Lot 2 were wintered in a four acre trap and fed the ration shown in Table I. During the

TABLE I (RATIONS)

	Lot 1 (20 Cows)	Lot 2 (20 Cows)	Lot 3 (12 Cows)
Winter Ration (November 20, 1946 to April 7, 1947)			
Prairie hay	None	Ad lib (17 lbs.)	None
Native grass pasture	12.25 acres	None	12.25 acres
Alfalfa hay*	8.2 lbs.	4.9 lbs.	None
Cottonseed cake*	None	None	3.2 lbs.
Salt	Ad lib (.04 lbs.)	Ad lib (.06 lbs.)	Ad lib (.11 lbs.)
Mineral mixture**	Ad lib (.13 lbs.)	Ad lib (.14 lbs.)	Ad lib (.05 lbs.)
Summer Ration (April 7, 1947 to November 7, 1948)			
Native grass pasture	12.25 acres	8.6 acres	12.25 acres
Salt	Ad lib (.06 lbs.)	Ad lib (.06 lbs.)	Ad lib (.08 lbs.)
Mineral mixture	Ad lib (.02 lbs.)	Ad lib (.04 lbs.)	Ad lib (.05 lbs.)

*The alfalfa hay and cottonseed cake were fed at levels to provide approximately the same amount of crude protein as fed in previous experiments which had given satisfactory results. The levels of hay and cake fed to the cows of Lots 1 and 3 were adjusted so that each lot received approximately the same total crude protein intake per day from the supplements.

**Mineral mixture composed of equal parts of common salt, ground limestone and steamed bonemeal.

summer months (April 7 to November 7, 1947) the cows of Lot 2 were grazed in a native grass pasture providing approximately 8.6 acres of native grass pasture, 1.6 acres of which consisted of previously cultivated land.

The alfalfa hay fed to the cows of Lot 2 was fed at a level to provide approximately the same crude protein intake as 1.3 pounds of cottonseed cake which had been found to satisfactorily supplement prairie hay, (Ross, et al 1947). The alfalfa hay fed to the cows of Lot 1 was fed at a level to provide approximately the same protein intake as 3.0 pounds of cottonseed cake which Ross, et al. (1947) had found to satisfactorily supplement dry cured grass for wintering pregnant cows.

The cows were pasture-bred to registered Hereford bulls. The bulls were placed with the cows on May 1, 1947 and removed September 1, 1947. Each two-week period the bulls were rotated among the lots as insurance against poor conception due to sterility or poor breeding performance of an individual bull. This same breeding procedure had been followed the season before Experiment I was started.

Blood samples were collected by venous puncture when the cows were placed on experiment and at approximately monthly intervals thereafter. During most of the year only ten cows of Lots 1 and 2 and eight cows of Lot 3 were bled, but during February, March, April and November all of the cows were bled. The blood was collected in citrated tubes. It was kept under refrigeration until aliquots were taken for the various chemical determinations. The chemical determinations made and methods employed were: Plasma calcium by the method of Clark and Collip, (1925); plasma inorganic phosphorus, Youngburg and Youngburg, (1930); plasma carotene and vitamin A, Kimble, (1939); and plasma ascorbic acid, Mindlin and Butler, (1938).

As soon after birth as the calves were found in the pastures, a sample of blood was obtained and the same determinations were made on the blood plasma of the calves as upon the blood plasma of the cows. All of the calves were bled on the April bleeding date but only those calves from the cows bled during the summer were bled after that date. These blood samples were taken on the same date that the cows were bled. The calves were not bled after August, 1947.

All calves were dehorned at approximately 2 months of age, and the bull calves castrated at about 1 month of age. All calves were vaccinated for blackleg.

The following records were maintained:

1. Gain or loss in weight of the cows.
2. Percentage calf crop born.
3. Birth weight of calves.
4. Weaning weight of calves.
5. Percentage calf crop weaned.
6. Records of all feeds fed.
7. Yearly feed costs.
8. Blood data.

The prairie hay fed in this experiment was grown in the same general area where the pastures were located.

All supplemental feeds fed were analyzed chemically by A.O.A.C. methods (1940). In addition, grass samples were collected periodically and analyzed chemically. The samples which were largely Big Blue Stem, Little Blue Stem, Indian and Switch grasses, were collected from approximately the same area in each of the pastures each time. The grass was cut one to two inches above the ground and collected in paper bags.

The data was analyzed statistically by the methods of Snedecor (1946).

Results:

Pertinent data relative to weights and feed costs are shown in Table II. The weight data of the cows and calves of Lot 3 cannot be compared directly to those of Lots 1 and 2 because of differences in age and previous production records.

TABLE II

Summary of Systems of Management

	Lot 1 Grazed year long Fed alfalfa hay	Lot 2 Grazed 7 months Fed prairie and alfalfa hay	Lot 3 Grazed year long Fed C.S.C.
No. of cows	20	20	12
Av. age of cows	4 yrs.	4 yrs.	9 yrs.
Av. weight per cow beginning winter period	968	968	1079
Date winter period started	11/20/46	11/20/46	11/20/46
Av. wt. per cow before calving	966	955	1029
Av. wt. per cow when turned to pasture (after calving)	820	830	903
Av. gain per cow up to calving	- 2	- 13	- 50
Av. gain per cow for winter period	-148	-138	-176
Date summer period started	4/7/47	4/7/47	4/7/47
Date summer period ended	11/7/47	11/7/47	11/7/47
Av. wt. of cows end of summer period	937	865	1039
Av. gain in wt. for the year	- 31*	-103*	- 40
Percent calf crop	100	95.0	83.3
Av. birth wt. per calf	74.0	72.0	73.0
Av. birth date of calves	3/6/47	3/10/47	2/28/47
Av. weaning wt. per calf	413**	362**	466
Percent of calf crop weaned	100	95.0	83.3
Percent cows pregnant (examined 10/21/47)	100	95.0	91.7
Cost of year's feed per cow (dollars)			
Bluestem grass	$ 21.00	$ 10.50	$ 21.00
Cottonseed cake	-	-	18.80
Alfalfa hay	13.55	8.11	-
1-1-1 Mineral mixture	.22	.29	.38
Salt	.12	.19	.34
Prairie hay	-	18.77	-
Total cost	$ 34.89	$ 37.86	$ 40.52

*Significant at 5% level **Significant at 1% level

FEED PRICES

43% Cottonseed cake	$ 95.00 ton	Lots 1 and 3 Bluestem grass	$ 6.00 head winter period
Alfalfa hay	24.00 ton	Lots 1 and 3 Bluestem grass	15.00 head summer period
Salt	.95 cwt.	Lot 2 Bluestem grass	10.50 head summer period
1-1-1 Mineral mixture	43.13 ton		
Prairie hay	16.00 ton		

Productive data of Lot 3 cannot be compared to that of Lots 1 and 2 because of differences in age and previous production record. The Lot 3 cows were not comparable to the other two lots when allotted.

The cows of Lot 3 were not comparable to the other two lots when allotted. They were a selected group of older cows that were in good health and considered good milkers and were included in this experiment primarily to study the blood constituents and winter feed costs.

The most significant differences observed in the weight of the cows of Lots 1 and 2 occurred at the conclusion of the experiment. The Lot 1 cows that were grazed year-long and fed alfalfa hay during the winter weighed 31 pounds less at the conclusion of the experiment than they did at the beginning. The cows of Lot 2 that were fed prairie hay and alfalfa hay during the winter lost 103 pounds during the year of the experiment. The difference in weight loss of the two lots was significant at the 5 percent level of probability. The unfavorable grazing season due to low rainfall during July, August, and September may have been partially responsible for the weight loss of the cows during the year.

The percentage of calves dropped in Lots 1 and 2 was 100 and 95 respectively. One cow of Lot 2 failed to calve but this failure was not considered to have been caused by the system of management or feeds fed. All cows were examined at the beginning of the experiment and thought to be pregnant but one cow was apparently open.

The calves of Lot 1 averaged 2 pounds heavier at birth than the calves of Lot 2 but this difference was not significant. The average weaning weight of the calves from the Lot 1 cows was 413 pounds as compared to 362 pounds for the calves from the Lot 2 cows. The difference in weight was significant at the 1 percent level of probability.

At the conclusion of the experiment a vegetative survey indicated that sufficient grass was available in each of the summer pastures and that the quantity of grass was not responsible for the large differences in the size of the calves at weaning or differences in the weight of the cows.

The Lot 3 cows, grazed year-long and fed cottonseed cake during the winter lost 40 pounds during the year of the experiment. One cow failed to calve accounting for the 83 percent calf crop dropped and weaned. The average weaning weight of the calves was 466 pounds. Although the calves of Lot 3 weighed 53 pounds more than the calves of Lot 1 at weaning, this difference was not considered due to the feeds fed because the cows of Lot 3 were not comparable to those of Lot 1. The cows of Lot 3 were a selected group of older cows that had consistently weaned heavy calves previous to the initiation of this experiment.

The feed cost per cow for the year was $34.89 for Lot 1, $37.86 for Lot 2, and $40.52 for Lot 3. No labor costs were included in this study.

The chemical analyses of the feeds fed plus the estimated daily calcium and phosphorus intake during the winter feeding period is given in Table III. It will be noted that the calcium-phosphorus ratio of Lot 1 was 6.5:1, of Lot 2, 7.4:1, and of Lot 3, 1.4:1.

The analyses for the various blood constituents of the cows are shown in Table IV.

The blood calcium levels in each of the three lots showed little variation throughout this experiment. The average calcium content of Lot 1 ranged from 10.0 to 12.2 mg. per 100 ml. of blood plasma. The range for the cows of Lot 2 was 10.0 to 12.8 mg. and for those of Lot 3 it was 9.9 to 11.4 mg. per 100 ml. of blood plasma. All values were within the accepted normal range.

Variations in inorganic plasma phosphorus were the most consistent of any blood constituents studied. The cows of Lot 2 had the lowest blood plasma phosphorus levels during the winter months and also during some of the months of the summer grazing season. The cows of Lot 3 had higher inorganic plasma phosphorus levels than those of the other two lots except for the initial bleeding and for the May, August, and September bleeding dates. Statistical analysis of the differences among the lots showed a significance at the 1 percent level of probability for the December, January, February, March, April, June, July 1, and

TABLE III

FEED ANALYSES (% DRY MATTER BASIS)

	D.M.	Ash	Protein	Fat	Fiber	N.F.E.	Ca.	P.	Carotene*
Cottonseed cake	92.61	7.57	41.90	5.52	12.49	32.52	.229	1.405	
Alfalfa hay	92.98	7.93	16.26	2.32	30.82	42.67	1.456	.223	31
Prairie hay	94.82	8.06	3.73	2.02	35.82	50.37	.530	.060	11
Bonemeal	97.35						32.19	15.05	
Ground limestone	99.67						36.18		
Grass 1/16/47	96.33	6.30	2.68	1.31	41.75	47.96	.362	.049	3
Grass 5/9/47	97.80	7.13	13.50	2.42	31.69	45.26	.365	.163	425
Grass 6/17/47	93.20	7.48	8.60	2.77	31.65	49.50	.390	.115	
Grass 8/28/47	93.14	6.86	4.45	2.31	31.21	55.17	.530	.062	
Grass 11/7/47	92.68	5.80	2.24	1.88	41.68	48.40	.313	.031	8

*Carotene expressed as parts per million.

Estimated Daily Calcium and Phosphorus Intake During Winter Feeding Period

	Calcium	Phosphorus	Ca/P Ratio
Lot 1	79.95 gms.	12.29 gms.	6.5
Lot 2	77.32	10.48	7.4
Lot 3	36.50	25.33	1.4

The above calculations were based upon the assumption that the cows of Lot 3 consumed the same poundage of dry grass as the cows of Lot 2 consumed of prairie hay. It was also assumed that the cows of Lot 1 consumed only 15# of dry grass per head per day. This assumption is based on information obtained from other experimental work.

TABLE IV
Blood Constituents of Cows (Averages by lots)
(Expressed as units per 100 ml. of blood plasma)

Date Bled	11/25/46	12/19/46	1/16/47	2/4/47	3/5/47	4/7/47	5/5/47	6/3/47	7/1/47	7/31/47	8/28/47	9/27/47	11/7/47
						Calcium (mg/100 ml)							
Lot 1	10.6	10.1	10.0	11.1	10.7	10.5	10.4	11.1	10.2	10.7	11.0	12.2	10.7
Lot 2	10.4	10.4	10.1	11.2	11.4	11.0	10.7	11.7	11.0	11.1	11.7	12.8	10.3
Lot 3	10.0	10.0	10.0	10.7	10.6	9.9	10.5	10.4	10.2	10.3	11.1	11.4	10.6
						Phosphorus (mg/100 ml)							
Lot 1	3.4	4.1**	4.2**	4.1**	4.0**	3.9**	5.0*	3.0**	3.5**	3.5**	4.5	3.3	2.7*
Lot 2	3.2	2.1	2.3	2.2	2.3	3.2	4.7	2.2	2.8	2.4	4.4	3.3	2.2
Lot 3	2.5	6.9	7.4	6.1	6.1	4.8	3.4	3.6	3.7	4.4	4.2	3.3	2.8
						Carotene (mcg/100 ml)							
Lot 1		328*	248**	225**	197**	400**	1106	1156	922	649	350	274	305**
Lot 2		264	194	180	113	194	956	1068	920	660	339	240	174
Lot 3		192	155	170	67	324	954	1127	926	693	304	296	222
						Vitamin A (mcg/100 ml)							
Lot 1			32.5	20.2	25.5*	22.9*	21.8	21.9	30.9	38.0	-	31.4	27.3**
Lot 2			26.4	30.4	19.8	24.3	18.1	27.3	34.7	34.3	-	26.4	21.1
Lot 3			23.5	13.2	16.9	17.6	17.8	25.1	34.0	33.6	-	27.7	23.0
						Ascorbic Acid (mcg/100 ml)							
Lot 1				380	297	216**	246	369	245	434	-	342	430
Lot 2				390	321	255	272	352	219	401	-	351	370
Lot 3				320	245	119	223	393	220	376	-	215	425

*Significant at 5% level. **Significant at 1% level.

July 31 bleeding dates. Significance was found at the 5 percent level for the May and November (1947) bleeding dates. The fact that the Lot 3 cows were consistently higher than the other two lots during the winter months can be logically explained by the fact that they were fed cottonseed cake which provided a greater phosphorus intake and in addition they ate more of the mineral supplement.

The low phosphorus values of the Lot 2 cows suggests that the phosphorus nutrition might not have been optimal for maximum performance even though they had access to a 1-1-1 mineral mixture (equal parts salt, ground limestone and steamed bonemeal).

Figure I shows a graphic picture of the inorganic plasma phosphorus levels of the three lots. It will be noted that Lot 2 was almost consistently lower than the 4 mg. percent level at which Black and associates (1943) at the Texas station noted deficiency symptoms in cattle grazing a phosphorus deficient range.

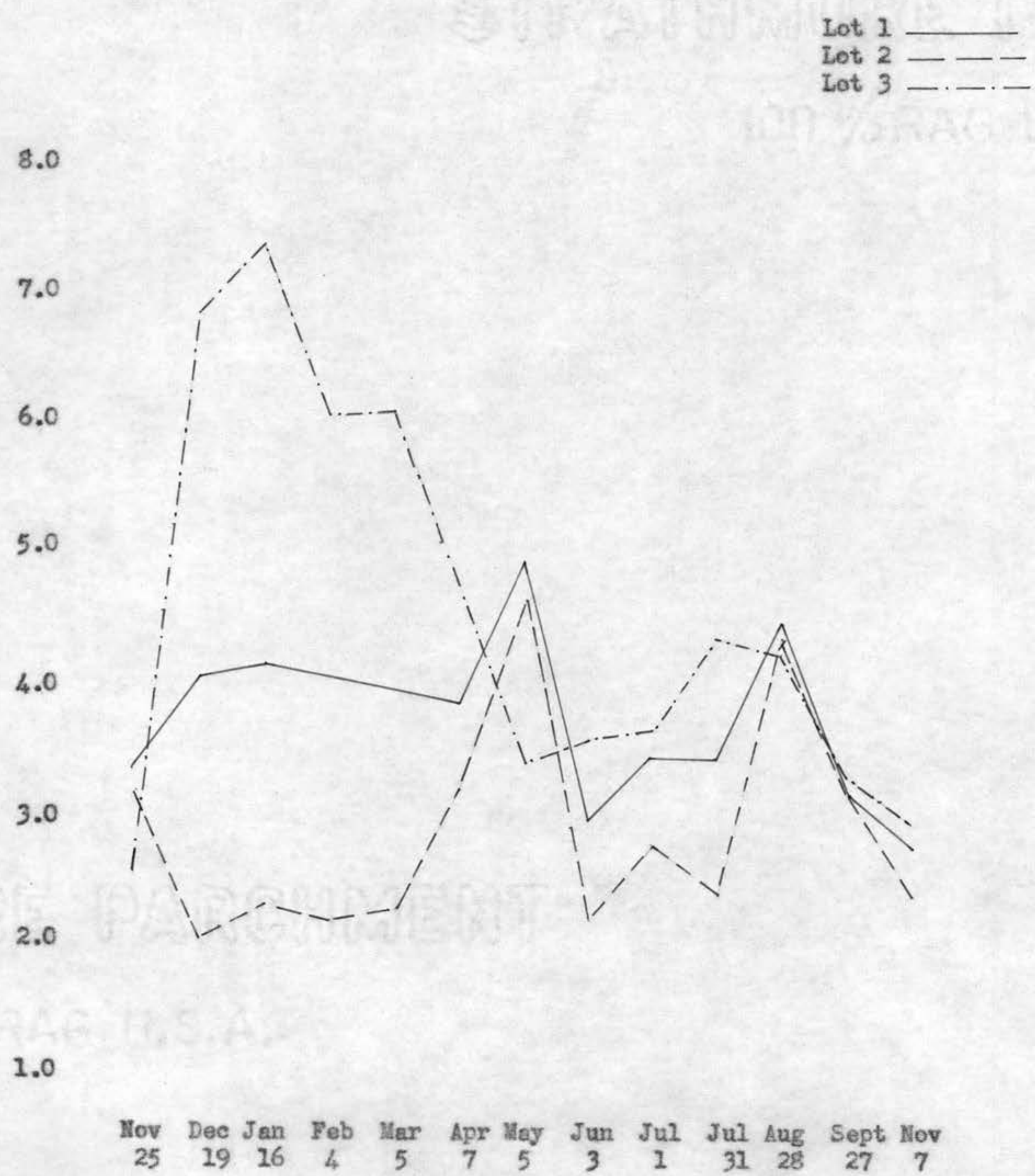
The cows of Lot 1 that were fed approximately 8 pounds of alfalfa hay during the winter were consistently higher in plasma carotene than those of the other lots during the months they were fed the hay.

There was a significant difference among the three lots at the 1 percent level of probability for blood plasma carotene for the January, February, March, April, and November (1947) bleedings. Significant differences at the 5 percent level of probability were found at the December bleeding. The differences during the winter months were to be expected due to the variation in carotene intake. There were no significant differences among lots during the summer months when green pasture was available to all three lots of cows.

The only significant differences in vitamin A were found at the March, April, and November (1947) bleedings. The March and April differences were significant at the 5 percent level of probability, and the November differences were significant at the 1 percent level of probability. In each instance the Lot 1 cows had the highest level of plasma vitamin A.

FIGURE 1

PHOSPHORUS (COWS) MG%



Significant differences in blood plasma ascorbic acid were found only during April and the differences were significant at the 1 percent level. No consistent trend was indicated from these data.

The analyses for the various constituents of the calves' blood are shown in Table V.

Although some variation was observed in the level of plasma calcium and inorganic phosphorus, the variation among lots was not consistent.

The level of carotene in the plasma of all calves was very low at birth. The Lot 1 calves had an average blood plasma carotene level of 6.1 mcg. per 100 ml. at birth as compared to 4.3 and 4.4 mcg. per 100 ml. for Lots 2 and 3 respectively. The plasma carotene in all lots rose rapidly during the first month as the calves grew older and the rise was very marked during those months when the grass made its most rapid growth (April and May). The values for all three lots decreased slightly in August.

The vitamin A level of the Lot 1 calves was highest at birth, being 11.4 mcg. per 100 ml. of plasma as compared to 10.4 for those of Lot 2 and 8.0 for those of Lot 3. The plasma vitamin A of the calves of all three lots increased rapidly during the first month.

Considerable variation was found in the plasma ascorbic acid levels of the calves within lots as well as among lots. The variations were not, however, consistent.

TABLE V

Blood Constituents of Calves (Averages by lots)

Dates Bled	Initial Bleeding***	3/5/47	4/7/47	5/5/47	6/3/47	7/1/47	7/31/47	8/28/47
				Calcium (mg/100 ml. plasma)				
Lot 1		13.1	10.2	11.9	11.7	10.8	10.6	11.3
Lot 2		12.5	11.5	11.7	12.3	10.9	11.2	11.5
Lot 3		12.0	11.5	11.7	12.3	10.9	11.2	11.5
				Phosphorus (mg/100 ml.)				
Lot 1	8.6	9.0	7.5	7.7	6.6	7.1	6.7	6.2
Lot 2	9.0	8.4	7.8	7.1	6.7	6.8	6.2	5.3
Lot 3	8.7	8.6	7.4	7.3	7.1	7.0	6.6	5.7
				Carotene (mcg/100 ml.)				
Lot 1	6.1	25.0	31.0	330*	546	720	575*	372
Lot 2	4.3	15.0	38.0	369	554	712	570	384
Lot 3	4.4	11.0	54.0	202	443	735	772	465
				Vitamin A (mcg/100 ml.)				
Lot 1	11.4	20.1	12.3	17.0	25.0	23.5	31.0	-
Lot 2	10.4	18.3	12.6	21.5	25.8	22.6	25.8	-
Lot 3	8.0	15.9	16.2	16.7	26.5	19.7	35.7	-
				Ascorbic Acid (mcg/100 ml.)				
Lot 1	330	481*	173	230**	402	306	402	238
Lot 2	390	507	92	303	400	396	485	188
Lot 3	440	333	105	138	420	374	583	161

*Significant at 5% level
**Significant at 1% level
***The calves were bled initially as soon as they were found in the pasture and ranged in age from 1 hour to 24 hours.

EXPERIMENT II

Procedure:

Experiment II was started November 7, 1947, and completed October 19, 1948.

Three comparable lots of 20 grade Hereford cows were used in this study. Most of the cows of Lots 1 and 2 of Experiment I were retained in the experiment and the other cows used were "coming" three-year-old bred heifers. The average age of the cows of each lot was the same. Insofar as possible, those cows that had been in Lots 1 and 2 in Experiment I were left in their respective lots for Experiment II.

During the winter period, (November 7, 1947 to April 18, 1948), all of the cows were bled at approximately monthly intervals. Only 10 cows of each lot were bled on the July, August, and September bleeding dates. Blood samples were taken from the calves at birth as in Experiment I, and at each regular monthly bleeding date thereafter; however, on the July and August bleeding dates, samples were taken only from the calves of the 10 cows that were bled.

The rations fed are shown in Table VI.

The grass samples were collected by species for chemical analysis. The four species collected were Big Blue Stem, Little Blue Stem, Indian, and Switch Grass. Triplicate samples were taken monthly. One sample was taken from a southeast slope, another from a north slope, and the third from a northeast slope.

All other methods of experimental procedure were the same as those followed for Experiment I.

Results:

The productive data for Experiment II are shown in Table VII.

The cows of Lot 1 made the greatest gain in weight up to calving time, (March 7, 1948). They gained 59 pounds while Lots 2 and 3 gained only 28 and 18 pounds respectively.

TABLE VI

Winter Ration
(November 7, 1947 to April 18, 1948)

	Lot 1 (20 cows)	Lot 2 (20 cows)	Lot 3 (20 cows)
Prairie hay	None	Ad lib (13.65 lbs)	None
Native grass (pasture)	12.25 acres	None	12.25 acres
Alfalfa hay*	8.54 lbs.	4.87 lbs.	None
Cottonseed cake*	None	None	2.56
Mineral mixtures**	Ad lib (.03 lbs)	Ad lib (.07 lbs)	Ad lib (.10 lbs)

Summer Ration
(April 18, 1948 to October 19, 1948)

	Lot 1	Lot 2	Lot 3
Native grass pasture	12.25 acres	8.6 acres	12.25 acres
Mineral mixture**	Ad lib	Ad lib	Ad lib

*The alfalfa hay and cottonseed cake were fed at levels to provide approximately the same amount of crude protein as fed in previous experiments which had given satisfactory results. The levels of hay and cake fed to the cows of Lots 1 and 3 were adjusted so that each lot received approximately the same total crude protein intake per day from the supplements.
**Mineral mixture composed of three parts of common salt to one part steamed bonemeal.

TABLE VII

Summary of Systems of Management

	Lot 1 Grazed year long Fed alfalfa hay	Lot 2 Grazed 7 months Fed prairie and alfalfa hay	Lot 3 Grazed year long Fed C.S.C.
No. of cows	20	20	20
Av. age of cows	4 yrs.	4 yrs.	4 yrs.
Av. wt. per cow beginning winter period	915	915	915
Date winter period started	11/7/47	11/7/47	11/7/47
Av. wt. per cow before calving	974	943	933
Av. wt. per cow when turned to pasture (after calving)	834	792	865
Av. gain per cow up to calving	59	28	18
Av. gain per cow for winter period	- 81*	-123*	- 50*
Date summer period started	4/18/48	4/18/48	4/18/48
Date summer period ended	10/19/48	10/19/48	10/19/48
Av. wt per cow end of summer period	1043	1030	1024
Av. gain in weight for the year	128	115	109
Percent calf crop	90.0	70.0	95.0
Av. birth date of calves	3/11/48	3/10/48	3/7/48
Av. birth weight per calf	76*	70*	71*
Av. weaning weight per calf	506*	451*	464*
Percent calf crop weaned	90.0	70.0	94.74
Percent cows pregnant (10/19/48)	100.0	100.0	95.0
Cost of year's feed per cow (dollars)			
Grass	$ 20.21	$ 14.19	$ 20.21
Cottonseed cake			20.63
Alfalfa hay	15.87	8.73	
Prairie hay		20.00	
Mineral mixture	.16	.21	.20
Total cost	$ 36.24	$ 43.13	$ 41.04

*Significant at 5% level **One cow of Lot 3 died (April 15, 1948)

FEED COSTS

43% Cottonseed cake	$100.00 per ton	Lots 1 and 3 Grass - winter period	$ 8.42
Alfalfa hay	22.00 per ton	Lot 2 Grass	14.19
Prairie hay	18.00 per ton	Lots 1 and 3 Grass - summer period	11.79
Mineral mixture	2.10 per cwt.		

All lots of cows lost weight during the winter period. The cows of Lot 2 lost 123 pounds and Lots 1 and 3 lost 81 and 50 pounds respectively. Most of the weight was lost during and after calving. The differences among lots in average weight of the cows at the end of the winter period were significant at the 5 percent level of probability.

The cows of Lot 3 grazed year-long and fed cottonseed cake during the winter raised a 95 percent calf crop while those of Lots 1 and 2 raised a 90 and 70 percent calf crop respectively. One cow of Lot 3 died during the winter. The cause of death was unknown but neither the system of management nor the ration was considered responsible for the death. The percentage calf crop of Lot 3 was calculated for 19 cows.

Six calves from the cows of Lot 2 were dead at birth or died shortly thereafter. Although some were born during a period of extremely cold weather this was not considered the primary cause of death. All calves were posted. The following observations were made:

Calf from cow 49: Appeared to have had some air in its lungs, but they were not completely inflated. The calf died very shortly after birth.

Calf from cow 64: Appeared to have inflammed intestines. The calf's lungs were normal. It had not nursed.

Calf from cow 69: Appeared to be deformed but upon examination the bones and joints were found to be normal. The tendons appeared loose and the joints could be turned in any direction. The internal organs were very bleached and the liver very light in color. The calf was born dead, its eyeballs were undersize and its lungs had not been inflated.

Calf from cow 142: Had only a very small amount of air in one of its lungs. Apparently died shortly after birth.

Calf from cow 113: Had not taken a breath. There was considerable fluid in the trachea and lungs. The other organs appeared to be normal. The center of the lens in each eye was cloudy. After the lens had been placed in a petri dish for one hour the cloudiness disappeared.

All of the calves of Lot 2 which were dead at birth or died shortly thereafter were born during, or shortly after an extremely cold period. Normal calves were dropped in the other lots at this time. No abnormal or dead calves were dropped in Lot 2 after the extreme cold had subsided.

The average birth weight per calf for Lots 1, 2 and 3 was 76, 70 and 71 pounds respectively. The differences were significant at the 5 percent level of probability.

The difference in the weaning weights of the three lots of calves was also significant at the 5 percent level of probability. The three lots had average weaning weights of 506, 451, and 464 pounds for Lots 1, 2 and 3 respectively.

The average yearly feed costs per cow were $36.24, $43.13, and $41.04 respectively for Lots 1, 2 and 3.

Chemical analyses of the various feeds fed are presented in Table VIII. The figures presented for the grass analyses are averages of the three samples of each species collected.

The estimated daily calcium and phosphorus intake during the winter feeding period is presented in Table VIII. The calcium-phosphorus ratio of Lot 1 was 6.0:1, of Lot 2, 6.8:1, and Lot 3, 1.6:1.

Blood Analyses:

The blood analyses of the cows are shown in Table IX.

There was very little variation in the average calcium levels among the three lots. The range for Lots 1, 2 and 3 respectively were 9.7 to 11.3 mg.,

TABLE VIII

Feed Analysis (% Dry matter basis)

	D.M.	Ash	Protein	Fat	Fiber	N.F.E.	Ca.	P.	Carotene*
Cottonseed cake	90.70	6.65	43.99	4.60	12.56	32.20	.25	1.32	0.00
Alfalfa hay	91.22	7.61	16.38	2.28	28.70	45.03	1.23	.22	30.58
Prairie hay	92.61	6.73	3.63	2.36	32.85	54.43	.52	.05	9.18
Bonemeal	96.92	89.96					33.64	14.03	

*Carotene expressed as parts per million

Estimated Daily Calcium and Phosphorus
Consumption During Winter Feeding Period

	Calcium	Phosphorus	Ca/P Ratio
Lot 1	64.21 gms.	10.69 gms.	6.0
Lot 2	57.18	8.37	6.8
Lot 3	28.32	18.10	1.6

The above calculations were based upon the assumption that the cows of Lot 1 consumed 15# of grass, that the cows of Lot 3 consumed 17# of grass. The assumptions were based on information obtained from other experimental work.

TABLE VIII, Cont'd.

Grass Analysis (% Dry matter basis)

	D.M.	Ash	Protein	Fat	Fiber	N.F.E.	Ca.	P.	Carotene*
11/24/47									
Switch	91.37	5.29	2.11	2.10	38.10	52.40	.303	.031	.66
Little Bluestem	91.11	5.98	2.33	2.16	36.70	52.83	.315	.031	1.3
Big Bluestem	91.11	5.87	2.90	2.02	35.69	53.52	.353	.038	1.4
Indian	91.19	6.35	2.64	2.17	35.92	52.92	.326	.032	.77
12/17/47									
Switch	94.07	4.57	1.63	1.49	44.47	47.84	.266	.031	.43
Little Bluestem	92.98	6.24	2.96	1.91	42.92	45.97	.280	.031	.64
Big Bluestem	93.20	7.20	3.83	2.49	38.50	47.98	.279	.041	.75
Indian	93.24	5.98	2.10	1.81	44.02	46.09	.290	.031	1.29
1/16/48									
Switch	94.18	4.52	2.29				.308	.030	.287
Little Bluestem	93.98	6.12	2.67				.330	.048	.128
Big Bluestem	94.41	6.51	2.78				.339	.034	.13
Indian	93.98	6.27	2.21				.319	.042	.47
2/19/48									
Switch	92.59	4.49	1.86				.257	.037	.29
Little Bluestem	92.70	6.16	2.62				.275	.044	.27
Big Bluestem	92.44	7.81	3.28				.392	.064	.32
Indian	91.53	6.29	2.16				.315	.038	.55
4/14/48									
Switch	93.48	4.87	2.17	1.60	43.09		.265	.077	.021
Little Bluestem	93.65	6.19	3.65	1.84	37.81		.287	.035	1.68
Big Bluestem	93.34	7.33	3.77	2.27	39.15		.357	.036	.57
Indian	93.74	6.36	2.70	1.45	42.12		.270	.028	.028
5/14/48									
Switch	38.47	5.98	9.98	1.98	30.72	51.34	.286	.146	337.4
Little Bluestem	43.77	7.08	8.77	1.32	33.06	49.77	.356	.103	260.68
Big Bluestem	35.20	7.10	10.26	2.10	31.22	49.32	.327	.148	316.9
Indian	40.73	7.86	9.26	1.87	31.87	49.14	.368	.118	279.4

*Carotene expressed as parts per million.

TABLE VIII, Cont'd.

Grass Analysis (% Dry matter basis)

	D.M.	Ash	Protein	Fat	Fiber	N.F.E.	Ca.	P.	Carotene*
6/17/48									
Switch	46.08	5.75	5.86				.269	.098	173.48
Little Bluestem	53.82	7.02	5.67				.399	.072	155.26
Big Bluestem	42.80	5.98	6.64				.423	.082	222.31
Indian	49.79	6.65	6.35				.362	.070	238.34
7/17/48									
Switch	42.75	5.19	5.57	2.67	40.58	45.99	.250	.080	100.98
Little Bluestem	45.10	6.81	6.94	2.75	35.06	48.44	.388	.080	186.61
Big Bluestem	38.79	6.01	6.80	3.30	36.86	47.03	.392	.085	214.80
Indian	39.34	7.04	6.76	3.20	37.20	45.80	.302	.076	237.19
8/19/48									
Switch	41.02	5.60	5.22	2.36	46.54	40.28	.214	.085	127.57
Little Bluestem	41.41	3.55	5.19	2.17	45.81	43.28	.249	.098	109.95
Big Bluestem	35.72	5.90	5.96	3.30	41.18	43.66	.282	.092	209.01
Indian	37.81	5.66	4.81	2.22	46.60	40.71	.206	.084	171.11
9/23/48									
Switch	43.67	4.99	4.01	2.02	34.03	54.95	.234	.053	
Little Bluestem	45.70	3.46	3.76	2.06	39.84	50.88	.160	.061	
Big Bluestem	50.31	3.54	2.88	1.75	42.16	49.67	.177	.038	
Indian	45.83	4.52	2.94	1.68	38.42	52.44	.155	.054	
10/14/48									
Switch	70.15	6.03	2.92	1.65	40.42	48.98	2.64	.048	18.0
Little Bluestem	71.17	3.85	3.72	1.30	35.62	55.51	1.60	.055	14.0
Big Bluestem	63.64	4.07	3.33	1.40	36.49	54.71	1.65	.050	17.0
Indian	71.44	4.98	2.02	1.34	41.32	50.34	1.94	.049	7.46

*Carotene expressed as parts per million.

TABLE X

Blood Constituents of Cows (Averages by lots)
(Expressed as units per 100 ml. blood plasma)

	11/7/47	12/2/47	12/29/47	2/10/48	3/13/48	4/18/48	5/28/48	7/6/48	8/3/48	9/7/48	10/26/48[1]
Calcium (mg)											
Lot 1	10.6	10.5	10.6	10.3	10.9	10.7	10.4	11.3	9.7	11.1	
Lot 2	10.7	10.8	11.2	10.4	11.1	10.5	10.0	11.5	10.3	11.0	
Lot 3	10.8	10.6	11.8	10.1	10.8	10.4	9.5	10.5	9.3	10.4	
Phosphorus (mg)											
Lot 1	2.8*	3.1**	4.5**	3.3**	2.4**	4.8	4.7**	3.2**	4.2**	3.3**	4.2**
Lot 2	2.4	2.8	3.4	3.5	1.7	4.0	4.8	2.2	3.0	3.0	3.2
Lot 3	3.0	3.5	5.8	4.7	5.1	4.3	6.2	4.0	4.3	4.7	5.4
Carotene (mcg)											
Lot 1	224	122	127**	121	115**	540**	1109	719	913	660	444
Lot 2	193	112	111	107	85	371	992	720	696	640	410
Lot 3	204	110	135	114	57	709	1122	928	908	643	406
Vitamin A (mcg)											
Lot 1	27.9	31.3**	29.7	24.6	22.4**	20.1*	21.0	28.2	29.7	47.5*	28.4
Lot 2	23.8	26.3	27.6	21.5	19.6	23.8	19.5	25.9	35.3	34.1	28.3
Lot 3	24.9	33.4	29.9	21.5	10.9	17.3	19.5	19.0	25.0	27.6	29.4
Ascorbic Acid (mcg)											
Lot 1	438	179*	210	281	86**	302	480	202	468	175	235
Lot 2	382	261	236	336	141	310	536	221	388	186	253
Lot 3	394	233	201	281	374	309	440	258	340	169	227

*Significant at the 5% level of probability.
**Significant at the 1% level of probability.
[1]No calcium determinations made.

10.0 to 11.5 mg., and 9.3 to 11.8 mg., per 100 ml., of blood plasma.

The cows of Lot 2 had consistently lower plasma phosphorus values than the other two lots.

There was a significant difference at the 5 percent level of probability in blood plasma phosphorus among the three lots on the initial bleeding date. The differences increased to the 1 percent level of probability for every bleeding date thereafter with the exception of the date that the cows were turned to pasture, (4-18-48). On that date the differences were not significant. A graphic picture of the phosphorus values for the cows is shown in Figure 2.

Highly significant differences (at the 1 percent level of probability) in carotene values among lots were found for the January, March, and April bleeding dates. The lowest carotene values observed in all lots occurred during March and the carotene values were highest during May after considerable green grass had become available. The lowest plasma carotene levels were observed in Lot 3 during the March bleeding. The average value for the lot was 57 mcg., per 100 ml., of blood plasma.

The only significant differences in plasma vitamin A were found on the December, March, April, and September bleedings with significance being shown at the 1 percent level of probability for the December and March bleedings and at the 5 percent level in April and September.

There was very little variation among the three lots in blood plasma ascorbic acid except during the December and March bleedings. The differences for the December bleeding were significant at the 5 percent level and the March differences were significant at the 1 percent level of probability.

The blood analyses of the calves are shown in Table X.

Calcium values were determined only on the April, May, June, July, and August bleedings. These values showed little variation and were considered normal.

FIGURE 2

PHOSPHORUS (COWS) MG%

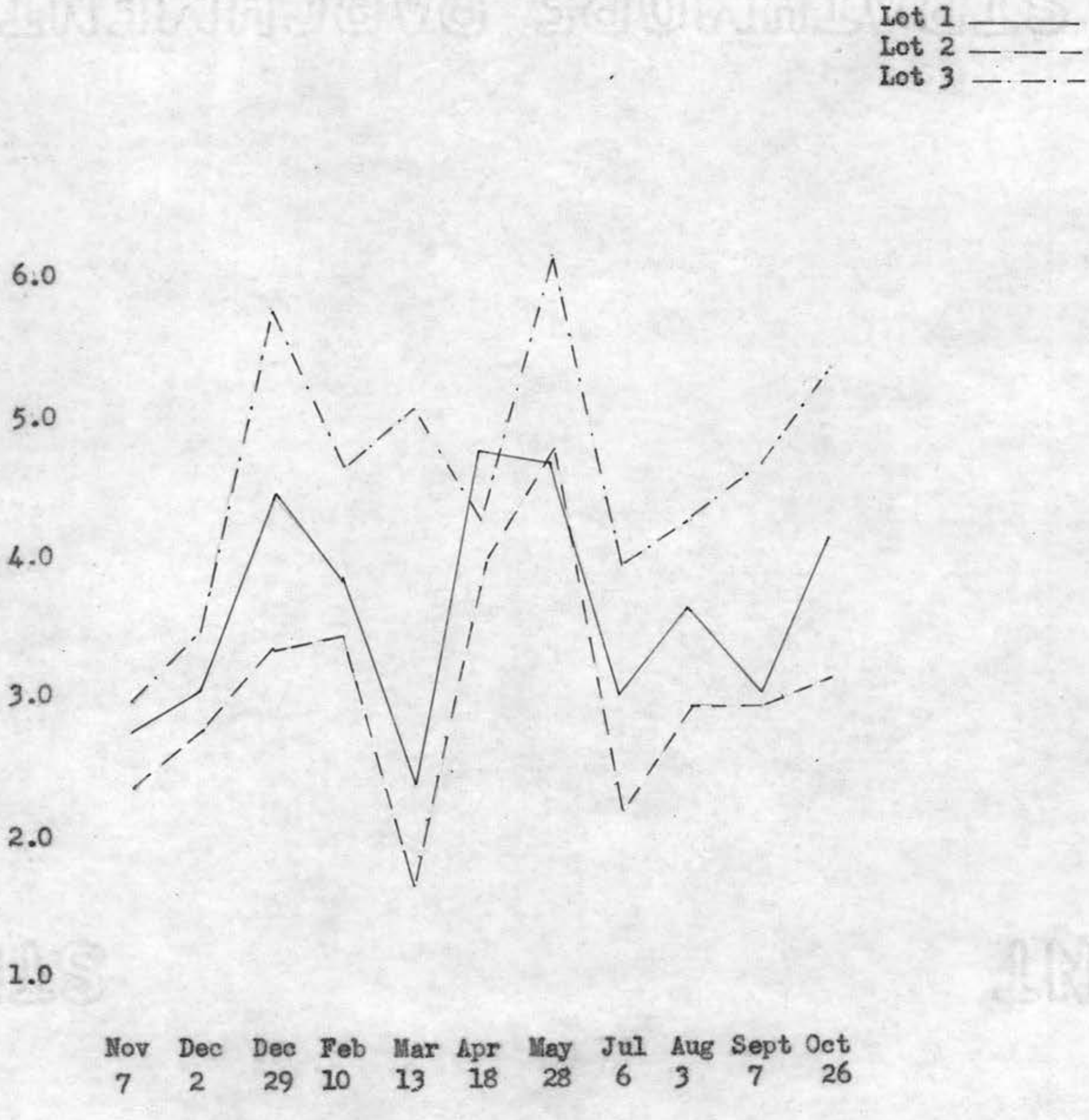


TABLE X

Blood Constituents of Calves
(Averages by lots)

	At birth	3/13/48	4/18/48	5/28/48	7/6/48	8/3/48
			Calcium (mg per 100 ml)			
Lot 1			11.1	11.5	11.4	10.3
Lot 2			11.1	10.5	11.6	10.7
Lot 3			11.2	10.4	11.7	9.9
			Phosphorus (mg per 100 ml)			
Lot 1	5.7	7.0	8.6	11.5**	7.3**	8.0**
Lot 2	5.3	6.6	8.0	10.9	6.3	6.9
Lot 3	6.8	5.9	8.6	13.0	7.3	8.4
			Carotene (mcg per 100 ml)			
Lot 1	6.9	20.0**	267*	340	526	585
Lot 2	4.0	14.0	158	300	483	526
Lot 3	5.9	10.0	115	403	476	592
			Vitamin A (mcg per 100 ml)			
Lot 1	7.5	22.1**	21.4	24.0	25.4	34.5
Lot 2	9.2	16.0	17.8	20.5	27.7	39.1
Lot 3	10.2	9.6	19.8	20.7	25.5	34.9
			Ascorbic Acid (mcg per 100 ml)			
Lot 1	436	163**	342	685**	316	389*
Lot 2	359	191	408	759	367	546
Lot 3	358	448	328	568	360	482

*Significant at the 5 percent level of probability.
**Significant at the 1 percent level of probability.

With the exception of the March bleeding, the phosphorus values of the calves of Lot 2 were the lowest of the three lots. Significant differences among the three lots of calves on May, July, and August bleeding dates were observed but all values were well within the accepted normal range.

The calves of Lot 1 had the highest average carotene value at birth (6.9 mcg., per 100 ml.) and the calves of Lot 2 had the lowest value at birth (4.0 mcg., per 100 ml.). The plasma carotene levels of the calves of Lot 1 were also the highest of the three lots on the March and April bleeding dates, and the differences among lots were statistically significant during these months.

The Lot 3 calves had the highest blood plasma vitamin A level at birth. The greatest difference among the lots occurred on the March 13 bleeding. This difference was significant at the 1 percent level of probability. In general, the average value for each of the three lots increased gradually from birth up to the weaning date.

No definite trend was indicated from the ascorbic acid.

DISCUSSION

Systems of Management:

In this study, the most economical method of management of commercial cows was to graze them year-long and feed alfalfa hay during the winter months. In Experiment I, the yearly feed cost per cow for the group grazed year-long (Lot 1) and the group wintered in the trap (Lot 2) was $34.89 and $37.86 respectively. Essentially the same relative relationship existed in Experiment II.

In Experiment I the cows of Lot 1 lost 2 pounds up to time of calving and lost 31 pounds per cow during the year of the experiment. The cows of Lot 2 lost 13 and 103 pounds, respectively, during the same period. The calves from the cows of Lot 1 that were grazed year-long were 2 pounds heavier than those of Lot 2 at birth and 51 pounds heavier at weaning. The same general trend was observed in Experiment II. The cows of Lots 1 and 2 gained 59 pounds and 28 pounds respectively up to time of calving. The cows of both lots gained considerable weight during the year. The yearly gain in weight for Lots 1 and 2, respectively, was 128 and 115 pounds. The calves produced by the cows grazed year-long were significantly heavier than those of Lot 2 that were wintered in the trap. The calves of Lot 1 were 51 pounds heavier than those of Lot 2 and this difference was significant at the 1% level of probability. The cows of Lot 1 also weaned 20% more calves than the cows of Lot 2.

The unfavorable grazing season due to dry weather during July, August and September may have been partially responsible for the loss in weight of both lots of cows during the year of Experiment I. The grazing season during Experiment II was very favorable.

The system of grazing cows year-long in native grass pastures and supplementing the winter grass with approximately 8.5 pounds of alfalfa hay daily was a better system of management than grazing for 7 months and wintering in a trap with prairie hay and supplementing with approximately 4.5 pounds of alfalfa hay daily per cow. The yearly feed cost was less for the year-long grazed cows and in addition the cows were heavier at the conclusion of the experiment than the trap fed cows of Lot 2. The most significant differences in favor of the system of grazing year-long was the difference in the average birth and weaning weight of the calves.

Protein Supplements:

Yearly feed cost is the only item which can be logically compared of the data of Lots 1 and 3 of Experiment I because of the difference in the age and previous history of the two lots of cows used in this experiment. The yearly feed cost of the cows of Lot 1 that were fed alfalfa hay was $5.63 per head less than that of the cows of Lot 3 that were fed cottonseed cake. In Experiment II the difference was $4.80 per head, again in favor of the Lot 1 cows.

In Experiment II, the average gain in weight of the cows of Lot 1 (alfalfa fed cows) was 41 pounds greater up to the time of calving than that of the cows of Lot 3 (cake fed cows). The difference in weight at the end of the year was 19 pounds per cow in favor of the Lot 1 cows. The Lot 3 cows weaned a 95 percent calf crop which was 5 percent greater than the cows of Lot 1, but the calves from the cake fed cows weighed 5 pounds per calf less at birth and 42 pounds per calf less at weaning than did the calves of the cows that were fed alfalfa hay during the winter.

Although the data of Experiment II is the only data which can be compared relative to the merit of the two supplements, it appears that the system of grazing cows year-long and feeding them a protein supplement of 8.5 pounds of alfalfa hay during the winter months is a more practical system of management for the Stillwater area of Oklahoma than the system of grazing year-long and feeding 2.56 pounds of cottonseed cake during the winter.

Blood Constituents of Cows.

Examination of the data show that the plasma calcium levels of the cows in both Experiment I and Experiment II were within the normal range for beef cattle. This, together with chemical analyses of feeds fed, suggested that the calcium nutrition of these cows was apparently adequate.

The estimated calcium/phosphorus ratio during the winter period in Experiment I was 6.5 for the Lot 1 cows, 7.4 for the Lot 2 cows, and 1.4 for the Lot 3 cows. In Experiment II the ratio for the winter period was 6.0 for Lot 1, 6.8 for Lot 2, and 1.6 for Lot 3. Bohstedt (1942) and other workers reported that the absolute amount of calcium and phosphorus in the dietary is of greater significance to the well being of the animals than the ratio between the two elements. Haag, Jones, and Brandt (1932) indicated that a calcium/phosphorus ratio of 10.5 was no worse than one of 7.6 for dairy cattle.

The plasma inorganic phosphorus values of the cows showed considerable variation among lots in both Experiment I and Experiment II during the winter months and some of the summer months. The average phosphorus level of the cows of Lot 1 was 4.0 mg. per 100 ml. of blood plasma for the winter period in Experiment I and 3.6 mg. per 100 ml. of plasma for the same period in Experiment II. The average phosphorus value for the Lot 2 cows was 2.6 mg. per 100 ml. for the winter period in Experiment I and 3.0 mg. per 100 ml. in Experiment II. Values of 5.8 mg. per 100 ml. of plasma for the winter period in Experiment I and 4.4 mg. per 100 ml. in Experiment II were found in the cows of Lot 3.

The fact that the phosphorus consumption for most lots in both experiments was barely within the minimum range suggested by the National Research Council (1945) might partly explain the low blood plasma values that were found. The plasma phosphorus values observed were in general, lower than those values reported by Black and Associates (1942) who described symptoms of a phosphorus deficiency that developed in cattle when the blood phosphorus content was below 4 mg. per 100 ml. of whole blood. The values were also lower than those reported by Huffman and others (1933) and Greaves, _et al._, (1934). However, the values were in good agreement with those reported by Knox, Brenner, and Watkins (1941) of the New Mexico station. These workers observed values as low as 2 to 3 mg. percent in winter and spring, and values of from 3 to 4.5 mg. percent in the summer and reported that their cattle remained in excellent health.

The cows in both experiments were in good health and showed no gross symptoms of phosphorus deficiency. The small percentage of live calves born in Lot 2 of Experiment II might, in part, be attributed to a phosphorus deficiency but definite proof was lacking. The cows of Lot 2 had the lowest plasma phosphorus levels in both experiments and they were lower than the level reported at which phosphorus deficiency symptoms have appeared. Theiler, Green, and Dutoit (1929) and Black and Associates (1943) found that cows in a good state of phosphorus nutrition had a higher percent calf crop than did cows that were phosphorus deficient.

The average estimated phosphorus consumption during the winter period for Lots 1, 2 and 3 in Experiment I was 12.29, 10.48 and 25.33 grams, respectively. In Experiment II the estimated daily consumption was 10.69 grams for Lot 1, 8.37 grams for Lot 2, and 18.10 grams for Lot 3.

Considerable seasonal variation of plasma carotene was observed in both Experiment I and Experiment II. The lots followed essentially the same trend during both experiments. Most of the variation could be explained by the carotene intake as affected by feeds fed. The cows receiving approximately eight and one-half pounds of alfalfa hay during the winter had the highest level of plasma carotene in both experiments during that season. During the summer months when the cows were grazing good pastures there was not a significant variation in plasma carotene among the lots. Davis and Madsen (1941) and Sutton and Soldner (1945) found marked fluctuation in blood carotene levels due to differences of carotene intake as affected by the season of the year.

The lowest plasma carotene values for the year in all lots of both experiments were observed at or near the average parturition date. This was due to the low carotene level of the grass at this time of the year and the depletion of body stores. Also, at the average parturition date part of the cows were in the latter stages of gestation and part of them were in the early stages of lactation.

Gallup and Kuhlman (1941), Sutton and Soldner (1943), Kuhlman and Gallup (1944), and Sutton and co-workers (1945) observed a drop in plasma carotene levels a few days before parturition and a further drop immediately following parturition with dairy cattle.

The carotene levels of all lots remained within the accepted normal range throughout the year except during early March which was approximately the average parturition date. Payne and Kingman (1945) found that aged Hereford cows with carotene levels as low as 82.88 $\neq$ 4.11 mcg. per 100 ml. of plasma showed no symptoms of deficiency over a two year period. However, a carotene level of 97.18 $\neq$ 7.68 mcg. per 100 ml. of plasma produced retained placenta and nutritional abortion in range Hereford heifers. No carotene deficiency symptoms were observed in any of the cows in either of the two experiments covered by this study.

The carotene-vitamin A ratio in this study was similar to that reported by Braun (1945). Braun found a linear increase of plasma vitamin A with increasing carotenoid levels. He also found that when the carotene increased to a certain level the vitamin A level began to decrease with each increasing carotene level.

The plasma vitamin A values of the cows fluctuated with season and ration in both experiments. Davis and Madsen (1941), studying cattle on restricted levels of carotene intake, found that the vitamin A content of the blood plasma was dependent on the carotene intake and previous storage of these factors. Sutton and Soldner (1945) found that the average monthly range of plasma vitamin A for all the dairy breeds considered was from 18 mcg. per 100 ml. in June to 24 mcg.

per 100 ml. of blood plasma in October.

The average vitamin A values for all lots in both experiments reported herein were within the accepted normal range. The vitamin A values were, in general, lowest in early March. Approximately half the cows of each lot had already calved and were lactating. The other cows calved shortly after this period. Sutton and Soldner (1943) and Kuhlman and Gallup (1944), studying dairy cows, found that plasma vitamin A dropped at or immediately before perturition. A further drop was found immediately after perturition.

Examination of the data revealed that the average plasma ascorbic acid levels of the cows in all lots throughout this study remained within the accepted normal range. Although considerable variation of plasma ascorbic acid was found, a definite trend was not indicated.

Blood Constituents of Calves:

The calcium values of the calves remained within the accepted normal range throughout the course of this study. There was very little variation either among or within lots in either experiment.

The calves of Experiment I had higher blood plasma phosphorus values than the calves of Experiment II at the time of the initial bleeding. The calves of Experiment I, all lots combined, had an average plasma phosphorus content of 8.8 mg. per 100 ml. at birth and the level decreased gradually as the calves grew older. The average plasma content was 5.7 mg. per 100 ml., when the calves were approximately 5 months of age. The calves of Experiment II had an average plasma content of 5.5 mg. per 100 ml. at birth and at approximately 5 months of age the average was 7.7 mg. per 100 ml. of blood plasma. The relatively high plasma phosphorus content of the calves of Experiment II at 5 months of age can be partially accounted for by the heavier rainfall during the summer of 1948 than during the same season in 1947. Black, _et al_., (1943) reported that the phosphorus content of forage and rainfall were directly correlated in a positive manner.

There was only slight variation among lots in the average blood plasma carotene and vitamin A in either Experiment I or Experiment II. In Experiment I the average plasma carotene and vitamin A values of the calves at the time of the initial bleeding, all lots combined, were 4.9 and 9.9 mcg. per 100 ml. respectively. In Experiment II the initial average plasma carotene and vitamin A values, all lots combined, were 5.8 and 8.9 mcg. per 100 ml. respectively. There was a linear increase in both constituents as the calves increased in age.

There was some variation among lots of calves in blood plasma ascorbic acid of both experiments. However, in general there was much more variation within lots than among lots. At the time of the initial bleeding, the calves of Experiment I had an average plasma ascorbic acid level of 386 mcg. per 100 ml. and the calves of Experiment II had an average level of 384 mcg. per 100 ml. These values were about one-third those obtained by Grummer, et al., (1948) for newborn pigs.

SUMMARY

1. Under the conditions of these experiments, the system of grazing cows year-long and feeding 8.5 pounds of alfalfa hay was a more practical and economical method of handling commercial range Hereford cows than the system of grazing during seven months of the year and feeding approximately 5 pounds of alfalfa and 15 pounds of prairie hay in a small trap during the five winter months. The yearly feed cost of cows grazed year-long and fed alfalfa hay during the winter was less than the feed cost of cows which were grazed only seven months and fed alfalfa hay and prairie hay in a small trap during the winter. In addition, the cows grazed year-long were heavier at the conclusion of each year's experiment and produced more calves that were heavier at both birth and weaning than were the calves from the cows wintered in the trap.

2. In these experiments, alfalfa hay fed as a protein supplement was superior to cottonseed cake when fed on a protein equivalent basis. Range Hereford cows grazed year-long and fed a protein supplement of approximately 8.5 pounds of alfalfa hay during the winter months were maintained at a lower yearly feed cost and were heavier at the end of each experiment than cows grazed year-long and fed a protein supplement of approximately 2.5 pounds of cottonseed cake during the winter months. The alfalfa supplemented cows produced calves which were heavier at birth and at weaning than were the calves of the cows fed cottonseed cake.

3. The blood plasma calcium levels of all lots of cows were within the accepted normal range and showed little variation either within or among lots.

4. Statistically significant differences were obtained among lots in plasma inorganic phosphorus levels during most of each year. The cows fed prairie and alfalfa hay in a trap during the winter had the lowest levels during the winter months and most of the summer months. Although typical phosphorus deficiency symptoms were not observed, the plasma phosphorus levels were low in

this lot which may have had some effect on both the cows and the calves produced. The cows fed cottonseed cake during the winter months had the highest phosphorus levels during the winter.

5. Seasonal variation in the plasma carotene and vitamin A levels were observed. Significant differences were obtained among lots but the only consistent differences were those for carotene during the winter phase of Experiment I. Those cows fed alfalfa hay had higher plasma carotene levels than the lot fed cottonseed cake. The lowest plasma carotene levels in all lots were found at the March bleeding date in both experiments. This bleeding date was near the average parturition date of the cows, suggesting the direct correlation between lactation and decrease in plasma carotene level.

6. The plasma ascorbic acid levels of all lots showed as much variation within lots as among lots and no definite trend was indicated.

7. The blood plasma calcium levels of all lots of calves were within the accepted normal range and showed little variation.

8. Significant differences in plasma phosphorus were obtained at the 1 percent level of probability among lots of calves at the June, July, and August bleeding dates of Experiment II.

9. The carotene and vitamin A plasma levels of the calves increased markedly from birth to weaning but little variation was found among lots.

10. The plasma ascorbic acid level of the calves from three lots showed considerable variation but in most cases there was as much variation within lots as among lots.

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