THE VALUE OF SUPPLEMENTAL VITAMIN A AND E AND TRACE MINERALS FOR WINTERING RANGE BEEF COWS

By

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TABLE OF CONTENTS

Page

INTRODUCTION 1

REVIEW OF LITERATURE 2

Vitamin A 2
Vitamin E 8
Trace Minerals. 12

MATERIALS AND METHODS. 16

RESULTS AND DISCUSSION 24

Production Data 24
Conception Rate. 24
Calf Survival. 24
Birth Date of Calves 26
Birth Weight of Calves 26
205-Day Adjusted Weaning Weight. 30
Average Daily Gain of Calves 34
Weaning Grade and Condition. 34
Winter Weight Changes of the Cows. 41
Blood Plasma Composition. 47

SUMMARY. 57

LITERATURE CITED 59

LIST OF TABLES

Table		Page
I.	Experimental Design.	16
II.	Composition of Trace Mineral Premix[a]	17
III.	Mineral Composition of Feeds	20
IV.	Proximate Composition of Feeds	22
V.	Affect of Vitamin and Trace Mineral Supplementation on Conception Rate of Cows	25
VI.	Affect of Vitamin and Trace Mineral Supplementation on Calf Survival	27
VII.	Analysis of Variance for Birth Date.	28
VIII.	Affect of Vitamin and Trace Mineral Supplementation on Birth Date.	29
IX.	Analysis of Variance for Birth Weight.	30
X.	Affect of Vitamin and Trace Mineral Supplementation on Birth Weight.	31
XI.	Analysis of Variance for 205-Day Adjusted Weaning Weight	32
XII.	Affect of Vitamin and Trace Mineral Supplementation on 205-Day Adjusted Weaning Weight	33
XIII.	Analysis of Variance for Average Daily Gain of Calves.	35
XIV.	Affect of Vitamin and Trace Mineral Supplementation on Average Daily Gain of Calves.	36
XV.	Analysis of Variance for Weaning Grade of Calves	37
XVI.	Affect of Vitamin and Trace Mineral Supplementation on Weaning Grade of Calves	38
XVII.	Analysis of Variance for Weaning Condition of Calves	39

Table		Page
XVIII.	Affect of Vitamin and Trace Mineral Supplementation on Weaning Condition of Calves	40
XIX.	Analysis of Variance for Winter Weight Change of Cows. . . .	42
XX.	Affect of Vitamin and Trace Mineral Supplementation on Winter Weight Changes of Cows	43
XXI.	Temperatures and Rainfall During the Experiment, Compared to the Normal	44
XXII.	Estimated Carotene Intake of Cows.	45
XXIII.	Estimated Dietary Alpha-Tocopherol Intake of Cows.	46
XXIV.	Estimated Intake of Trace Minerals of Cows.	48
XXV.	Affect of Trace Mineral Supplementation on Blood Plasma Levels of Cows.	49

LIST OF FIGURES

Figure | Page

1. Influence of Trace Minerals on Plasma Calcium Level 50
2. Influence of Trace Minerals on Plasma Phosphorus Level. 51
3. Influence of Trace Minerals on Plasma Magnesium Level 52
4. Influence of Trace Minerals on Plasma Zinc Level. 53
5. Influence of Trace Minerals on Plasma Copper Level. 54
6. Influence of Trace Minerals on Plasma Potassium Level 55

INTRODUCTION

Vitamin A nutrition has received much renewed interest in recent years. Part of this interest can be attributed to the fact that vitamin A can now be synthetically produced very cheaply. Since vitamin A has become inexpensive, it has been used by many cattle producers as insurance against a vitamin A deficiency. This study was designed to study the influence of vitamin A injections on the performance of range beef cows.

Previous work at this station has indicated that vitamin A injections results in heavier weaning weights. It was thought a more complete and comprehensive study would permit more definite conclusions to be made.

There has been very little work on the influence of vitamin E on range beef cows. Vitamin E was included in this study to determine its influence on the performance of range beef cows.

Earlier work at this station has shown that the addition of trace minerals to the diet of range beef cows did not improve performance. However, zinc and manganese were not included in the previous studies. For this reason zinc and manganese were included in the trace mineral premix used in this research.

The purpose of this study was to determine the value of supplemental vitamin A, vitamin E and trace minerals for wintering range beef cows.

REVIEW OF LITERATURE

Vitamin A

Jones and co-workers (1926) demonstrated that vitamin A was required for normal growth of calves. Since that time vitamin A has been considered an essential nutrient for cattle.

Vitamin A is not present in plants and forages; however, carotene, the precursor to vitamin A, is found in nearly all plants and forages (Maynard and Loosli, 1962). There are four different forms of carotene which have vitamin A activity: alpha carotene, beta carotene, gamma carotene and cryptoxanthine. With the exception of yellow corn, which contains mainly cryptoxanthine, most of the carotene of feeds is in the form of beta carotene. In terms of activity, 0.6 mcg. of beta carotene is equivalent to 0.3 mcg. of vitamin A activity.

Hart and Guilbert (1933) reported the occurance of avitaminosis A in beef cattle during a drought in California during which the cows received no green feed for 9 months. The older cows were slower in exhibiting deficiency symptoms, with the most common symptom being night blindness. Also, a few of the cows showed ophthalmia with ulceration of the cornea, and some of the cows had retained placentas. Early calves were normal at birth but at about 10-12 weeks of age they became unthrifty and showed definite symptoms of a vitamin A deficiency. Late calves were either born dead or died 1-5 days after birth. The symptoms most commonly seen were birth of dead or weak calves, eye lesions, severe diarrhea in newborn calves and retained placentas in the cows.

In later work by Guilbert and Hart (1934), avitaminosis A was evident in beef cattle after 225-240 days on a ration devoid of vitamin A. After 282 days the reserves of vitamin A were exhausted and the animals were in critical condition. Also, it was shown that calves from heifers receiving a restricted intake of vitamin A during gestation developed severe diarrhea at 2-8 days of age.

Guilbert and Hart (1935) found that about 225 days were required to deplete the vitamin A reserves of cattle and set the minimum daily carotene requirement at 26-33 mcg. per kg. of body weight.

Moore (1939), working with Holstein and Ayrshire calves, found that the calves when placed on a low carotene ration at 40-90 days of age developed nyctalopia in 48-73 days. Also, at approximately the same time, papillary edema developed. An intake of 9 mcg. of carotene per lb. of body weight was not sufficient to prevent nyctalopia or an increase in papillary edema. However, a level of 16 mcg. of carotene per lb. of body weight was sufficient to maintain the plasma carotene level and to prevent nyctalopia and maintain fair general health.

Riggs (1940), using steer calves 3-5 months old, showed that the average length of time required for depletion of vitamin A reserves was 79± 17 days. By adding 1000 mcg. of carotene per 100 lb. of body weight to the depletion ration, the average time required for the occurence of night blindness was lengthened only 15 days.

Davis and Madsen (1941) reported that apparently normal calves were born in two cases to beef heifers that received 60 mcg. of carotene from high quality dehydrated alfalfa leaf meal per kg. of body weight previous to and throughout the gestation period. One of the calves gave signs of being deficient at about 1 month of age. Heifers receiving 30 and 45 mcg. of carotene produced deficient calves although the cows themselves remained apparently normal.

Payne and Kingman (1947) found that in order to support normal gestation the carotene blood plasma level of first-calf range Hereford heifers must be considerably higher than that for aged Hereford cows. Heifers with carotene blood plasma levels of 97.18 ± 7.68 mcg. per 100 ml. showed clinical symptoms (so-called nutritional abortions and cases of retained placentas) of a carotene deficiency. However, with aged cows an average carotene blood plasma level as low as 82.88 ± 4.11 mcg. per 100 ml. produced no clinical symptoms of carotene deficiency over a 2-year period.

Madsen and Davis (1949) found that cows fed levels of 1.4, 2.0 and 2.7 mcg. of carotene per 100 lb. of body weight did not produce normal calves. When the level of carotene was raised to 4.0 mcg. per 100 lb. of body weight, normal calves were produced by the cows.

Ross et al. (1949) used Hereford heifers and steer calves to study carotene supplementation of cattle wintered under range conditions. Yearling or weanling heifers fed the crude carotene concentrate made slightly more total gain than the control group, however the reverse was true for the steers. Under the conditions of this study a consistent advantage could not be demonstrated by increasing the carotene intake.

Watkins and Knox (1950), in studying the blood carotene levels of range beef cows, indicated that a vitamin A deficiency might occur only in cases of a prolonged drought or under extremely abnormal conditions. January and February were the months when the blood carotene levels were lowest. The average for the 2 months was 165 mcg. of carotene per 100 ml. of plasma.

Van Arsdell et al. (1950) fed Hereford cows carotene at levels of 38, 75 and 106 mg. per day during the last 45 days of gestation and first 30 days of lactation. No differences were noted in health or vigor of the calves.

Ross et al. (1951) studied the relative value of alfalfa hay and cottonseed cake for winter feed in a commercial beef herd. The cows grazed native pasture; one group received cottonseed cake as a supplement and the other group received alfalfa hay. The results showed that approximately 8 lb. of alfalfa hay satisfactorily replaced 2½ lb. of cottonseed cake as a protein supplement. Plasma carotene and vitamin A indicated that both groups of animals received adequate amounts of these nutrients.

Baker (1953) demonstrated that beef cows receiving 60 mg. of carotene per head daily were unable to maintain liver stores of vitamin A during gestation. Increasing the carotene intake to 300 mg. during lactation had a sparing effect on the liver vitamin A reserve. It was also noted that vitamin A in the plasma and liver of the calves was closely associated with the carotene intake of the dam during lactation, but was also influenced by the liver stores of the cow at parturition. In the same study, four cows which were fed a low carotene ration for 32 months exhibited a remarkable ability to maintain themselves. However, the output of vitamin A in the milk was not sufficient to protect the calves from avitaminosis A. The eight calves produced in the 2 year study developed symptoms typical of a vitamin A deficiency between 1 and 6 weeks of age.

Watkins and Knox (1954) studied the supplemental feeding of carotene for range breeding cows during the precalving and calving period. They compared the carotene and vitamin A in the blood of cows receiving the protein supplement plus carotene to the cows which received the protein supplement and no carotene. Dehydrated alfalfa meal was used as the carotene supplement. The blood carotene of the cows fed the protein supplement alone was well above the requirements, as shown by various workers, indicating no major deficiency over an 8 year period even in the most critical season. Another observation was the feeding of the mixture containing 23% dehydrated alfalfa meal did not raise the plasma carotene over that of the cows fed no extra carotene; there was no significant difference in the plasma carotene and vitamin A content of the two groups.

Church (1956) reported on an experiment designed to study the rate of depletion of vitamin A reserves in beef cows and the effect of different levels of nutrition on the vitamin A requirement of beef cows nursing calves. He found that the depletion rate of liver vitamin A was quite rapid during the early months of the 3 year study. As the experiment progressed, the depletion of the liver stores continued, but at a decreasing rate. Although, all calves in the first and second year were normal at birth, vitamin A deficiency symptoms were definitely present at 6 weeks of age. In the third year all of the cows aborted during the seventh month of pregnancy.

Daniel (1957), after depleting the body stores of vitamin A and carotene in beef cows during the last 6 months of gestation, fed supplemental carotene to supply 10, 20 and 30 mg. per 100 lb. of body weight for the first 3 months of lactation. No deficiency symptoms appeared in the cows or calves. Also. the different levels of carotene intake during early lactation had no consistent affect on calf weights at 3 months of age.

Repp and Watkins (1958) reported that in a 3 year study of range cattle the blood plasma carotene did not drop below normal levels except for short periods during the winter. No visual clinical symptoms of a vitamin A deficiency were observed in the cows.

Pope _et al_. (1958) studied the affect of different levels of carotene intake during early lactation on beef cows which had been partially depleted of their vitamin A stores prior to calving. The cows were divided into three groups and received 0, 5 or 10 mg. of carotene per 100 lb. body weight per day for the first 3 months of lactation. Data obtained indicated little affect of carotene supplementation on the weight changes of the cows or gain of the calves to 3 months of age.

German and Adams (1963) found that the injection of 2,000,000 I.U. of vitamin A per cow in September and again in March produced a 12% increase in calf crop in spring.

Totusek (1965), working with range beef cattle, found that the injection of 1,000,000 I.U. of vitamin A per cow just prior to calving had no apparent affect on the spring weight of the cows, time of rebreeding of the cows or on survival of the calves to 112 days. However, the calves from the cows which had been injected with vitamin A were heavier at weaning than the calves from the control group. It was also noted that fewer cows injected with the vitamin A were open the following year as compared with the cows not injected.

Melton and Ellis (1965) studied the influence of supplemental vitamin A on reproductive performance of range beef cows. One group of heifers was injected intramuscularly with 1,000,000 I.U. of vitamin A 4 weeks prior to the spring calving season and again at the beginning of the breeding season. A third injection of 1,000,000 I.U. was given 6 weeks later. The fourth, fifth and sixth injections of 1,500,000 I.U. of vitamin A each were administered during the calving and breeding season the following year. The reproductive performance of treated and untreated heifers was very similar. There was one dry heifer in the vitamin A treated group and two in the control group. The vitamin A treated heifers calved an average of 5 days earlier and had an average adjusted weaning weight of 23 lb. more than the control heifers.

Vitamin E

Evans and Bishop (1922) established that vitamin E is required for normal reproduction in rats. Since that time the use of vitamin E to alleviate the reproductive problems in cattle has received much attention.

Vitamin E (in the form of tocopherols) is found in the nonsaponifiable fraction of fats and oils and has four active, naturally occurring isomeric forms (Maynard and Loosli, 1962). The alpha form is the most active as measured by the cure of sterility in rats and by the prevention of dystrophy. Vitamin E is resistant to heat but is readily oxidized and can be destroyed by rancid fat. Vitamin E is widely distributed in most livestock feeds. Whole ceral grains, green forage and other leafy material (especially alfalfa) are good sources of vitamin E.

Tocopherol has been used successfully in the prevention of muscular stiffness in lambs. Willman et al. (1945) demonstrated that the treatment of ewes with tocopherol prior to lambing or treatment of lambs at birth and once a week thereafter eliminated the occurrence of stiff lambs. When tocopherol was injected into stiff lambs, six of seven lambs recovered, while five of six untreated lambs died.

Whiting et al. (1949) reported that administering of tocopherol to ewes did not prevent the occurrence of stiff lambs. However, the condition was cured by administering the tocopherol directly to the lambs. He also noted the incidence of stiff lambs was greater when alfalfa or mixed hay was fed than when non-legume hay was fed.

Proctor et al. (1958) compared selenium and alpha-tocopherol as preventatives of muscular dystrophy in lambs. The addition of 1 ppm selenium to the vitamin E deficient ration of ewes prior to lambing reduced the incidence of muscular dystrophy to 4.7% as compared to 44.0% for the controls and 13.3% for the ewes supplemented with 100 I.U. of tocopherol daily. From this study it appeared that selenium was more effective in preventing muscular dystrophy than was tocopherol.

Drake et al. (1960) reported an increase in weight gains of lambs and a lower mortality rate when an aqueous solution of sodium selenate was given orally to lambs.

Jolly (1960) found that calves which received 10 mg. or more of sodium selenate orally twice a month gained 52% more weight than the control calves.

Thomas et al. (1945) used 99 matched pairs of ewes to study the influence of vitamin E potent wheat germ oil on reproductive performance. The ewes received 60 c.c. of wheat germ oil orally preceding the breeding season and 10 c.c. per ewe weekly thereafter until each ewe lambed. The vitamin E supplemented ewes lambed 4 days later than the control group. The control group had a 137% lamb crop with 11% of the ewes failing to lamb, compared to the vitamin E supplemented group which had a 133% lamb crop with 9% of the ewes failing to lamb. When the data were regrouped according to breed, no consistent differences in reproductive performance were obtained.

Marion (1962) fed clinically normal, repeat-breeder cows that had failed to maintain pregnancy after three or more services 2 oz. of wheat germ oil once a week for 6 consecutive weeks. Of the 79 cows that were treated, 58 (73%) conceived after the first post-treatment service compared to 38 (43%) of the 88 untreated cows.

Gullickson and associates (1949) conducted a study to determine the role of vitamin E in the nutrition of cattle, especially as it relates to reproduction. A total of 30 animals, including second, third and fourth generation descendants were fed through their lives on rations providing adequate amounts of all nutritive factors known to be essential except vitamin E. Four control animals were fed supplements containing either alpha-tocopherol or mixed tocopherols. Organs of reproduction developed normally in animals of both sexes and in the females the estrus cycle occurred regularly starting at about 7 months of age. All calves were born normal in size and vigor and there were no retained placentas or abortions in the cows. Gullickson noted that after several months on the vitamin E deficient diet, all animals exhibited some degree of "tongue lolling." Also, a marked desire to lick fences or stall boards was observed. The feeding of a mineral mixture containing cobalt, manganese, copper, iron and magnesium had no visible affect in alleviating the above symptoms. During the experiment 13 of 28 animals fed the vitamin E poor rations died suddenly at ages ranging from 21 months to 5 years. Gullickson and Calverley (1946) showed that these sudden deaths probably resulted from cardiac injury induced by restricting the animals to a ration deficient in vitamin E.

Matrone et al. (1965) reported that a purified diet containing 570 mg. of alpha-tocopherol acetate per 100 lb. of ration did not sustain normal reproduction in yearling ewes. He found that many of the ewes did not conceive and the ones that did conceive carried their fetus almost to term but the fetus died in utero. The addition of alfalfa leaf meal at a level of 5% of the ration resulted in 9 ewes giving birth to 15 lambs. The gains made by these lambs from the 9 ewes were comparable to those obtained in the field.

Virtanen (1966), also working with a purified diet, found that many cows required several services before conceiving. This difficulty was corrected by feeding the cows 330-500 mg. of alpha-tocopherol per head daily.

Vitamin E has been used in the rations of feedlot steers by some workers. Barringer and Burroughs (1963), using 304 yearling steers, found the addition of 0.1 ppm of selenium to the low vitamin E, no hay finishing ration increased live weight gains 9%. They also found that the addition of 8 mg. of vitamin E per lb. of total ration increased live weight gains by 7%. When both selenium and vitamin E were added to the ration, an 8% increase in live weight gain was obtained. They concluded that the lack of additive response when selenium was added to rations containing supplemental or natural vitamin E indicated that selenium and vitamin E exert a common biological function.

Kohmeier and Burroughs (1962) found that the improvements in the gain of steers when fed vitamins A, E and K were less than half as large as when vitamin A was fed alone. This indicated interrelationships between vitamins A, E and K in beef cattle nutrition.

Totusek (1965) reported that the injection of vitamins A, D and E (1,000,000 I.U., 100,000 I.U. and 100 I.U., respectively) to calves at birth did not influence survival to weaning or 210 day weaning weights.

Trace Minerals

Trace minerals are required in minute amounts. Until recently it has been difficult to determine the small amounts of trace minerals that are present in plants and feeds. However, with the development of new laboratory techniques and equipment, this problem has been partially overcome.

Tillman (1964) listed the following 6 trace minerals as being definitely dietary essentials for cattle: iron, cobalt, copper, iodine, manganese and zinc.

Plumlee *et al.* (1953) used identical twin beef cattle to determine the value of trace mineral additions to a ration of ground corn cobs and Purdue Cattle Supplement A. One twin of each set received daily the following trace minerals: 3.0 gm. magnesium, 130 mg. manganese, 1.0 mg. cobalt, 25 mg. copper, 130 mg. iron, and 1.0 mg. zinc. The average daily gain for the twins receiving trace minerals was 0.94 and 1.20 lb. as compared to the controls which had an average daily gain of 1.57 and 1.45 pounds. When *ad libitum* feeding was done later in the trial, the twins receiving the trace minerals ate less cobs and grew at a slower rate.

Thomas et al. (1953) added cobalt, copper and manganese to a wintering ration which contained either urea or soybean meal. Hereford steers averaging 390 lb. were fed for a 168-day winter feeding period. There was no significant difference in the gains made by the control steers and those receiving trace minerals.

Koch et al. (1962) studied the value of trace-mineralized salt for steers on a fattening ration and also the effect the trace minerals would have on shrinkage when the steers were transported to market. The addition of trace-mineralized salt had no apparent effect on average daily gain, feed efficiency, carcass characteristics or shrinkage.

Smith et al. (1965) fed the trace minerals cobalt, iodine, copper, and zinc to steers on a prairie hay-limited sorghum grain ration in an effort to improve utilization of prairie hay. The minerals were added to supply 1.0 mg. cobalt, 1.1 mg. iodine, 52 mg. copper and 312 mg. zinc per head daily. The average daily gain for the three groups receiving the trace minerals was 0.88, 1.14 and 1.67 lb. as compared to 0.76, 1.28 and 1.66 lb. for the control group. They concluded that the addition of the trace minerals seemed to have little measureable affect on the steers.

Embry et al. (1965) found the addition of trace-mineralized salt to the ration of feedlot steers did not affect the rate of gain or feed consumption of the steers.

Nelson and Kuhlman (1961) reported that the addition of trace-mineralized salt (containing manganese, iron, copper, cobalt, iodine and zinc) was of no apparent value for increasing gains of yearling steers grazing native grass. During the 116-day period, the steers which received the trace minerals gained an average of 176 lb. and the control group gained an average of 172 lb.

Tillman and Sirny (1959) used identical twin Angus calves to study trace mineral supplementation of weathered range grass when fed in wintering rations of cattle. The results indicated that the addition of supplemental trace minerals did not stimulate gains in these steers. However, it was noted that the animals receiving the trace minerals exhibited more glossy hair coats than the controls. He suggested this was indicative of more natural oils in their hair.

Nelson _et al_. (1952), in a 3 year study, provided a trace mineral mix formulated to furnish per 100 lb. of body weight, 10 mg. iron. .2 mg. cobalt, .2 mg. iodine, 50 mg. manganese and 1 mg. copper. Weanling heifers were used and were allowed to run on native pasture. The yearly gain of the heifers was not improved by feeding the trace minerals. In two of the three years the general appearance of the cattle was not influenced, but in one year the heifers receiving the trace minerals exhibited longer hair coats and, in general, a less thrifty appearance. Nelson (1955) used the same combination of trace minerals in wintering rations for 2-year-old stocker cows. The gain from October to March for the stocker cows receiving the trace minerals was 55 lb. which the control group gained 48 lb.

Totusek _et al_. (1957), in a five year study, added 10 mg. iron, 1.0 mg. copper, 0.2 mg. cobalt and 0.2 mg. of iodine per 100 lb. of body weight to the winter supplement of range beef cows. They found no significant difference in the yearly weight changes of the cows. The first year the calves from the cows receiving the trace minerals averaged 23 lb. heavier at weaning than the calves from the control group. However, this pattern was not repeated in the following 4 years. The general appearance of the cows and calves from both groups was similar for the entire experiment.

MATERIALS AND METHODS

A three-year experiment was initiated in the fall of 1963 to determine the value of supplemental trace minerals and injected vitamins A and E for reproducing, lactating beef females under range conditions. The design of the experiment is presented in Table I.

TABLE I

EXPERIMENTAL DESIGN

	West Pastures				East Pastures			
Lot No.	1	2	3	4	5	6	7	8
Trace Minerals	yes	no	yes	no	yes	no	yes	no

Within each lot the following vitamin treatments were imposed: no vitamins, vitamin A injected, vitamin E injected, and vitamins A and E injected.

The trace minerals fed were copper, iodine, zinc, iron, cobalt and manganese. A commercial trace mineral premix, fortified with zinc (in the form of zinc oxide) and copper (in the form of copper sulfate), was used to supply these minerals. Composition of the premix is shown in

Table II. A total of 1.25 lb. premix, 225 gm. zinc oxide and 30 gm. copper sulfate was blended with 100 lb. soybean meal, mixed with 900 lb. soybean meal at a local feed mill and pelleted into 5/8 in. pellets.

TABLE II

COMPOSITION OF TRACE MINERAL PREMIX[a]

Element	Source of Element	Percent of Element in Premix
		%
Manganese	Manganous oxide	7.00
Iodine	Calcium iodate	0.20
Copper	Copper oxide	1.00
Cobalt	Cobalt carbonate	0.10
Zinc	Zinc oxide	8.00
Iron	Ferrous Carbonate	10.00

[a] Obtained from Dawe's Laboratories, Inc., Chicago, Illinois.

The first year the vitamins were injected November 11, 1963; February 2, 1964; and April 21, 1964. The second year they were injected September 25, 1964; January 8, 1965; and May 1, 1965. The third year the vitamins were administered December 18, 1965; February 5, 1966; and June 16, 1966.

The first year vitamin A was injected at a level of 1,000,000 I.U.

per cow in November and 2,000,000 I.U. per cow in February and April. The second and third winters, the level was increased to 2,000,000 I.U. per cow in the fall and 4,000,000 I.U. per cow in the winter and spring. The vitamin A was in the form of vitamin A palmitate in sesame oil with 2% benzyl alcohol.

Vitamin E was injected on the same days as vitamin A. The vitamin E was injected at a level of 500 mg. per cow in the fall and 1000 mg. per cow in the winter and spring the first year. The level of vitamin E was increased to 1000 mg. per cow in the fall and 2000 mg. per cow in the winter and spring the second and third years. The vitamin E was in the form of alpha-tocopheryl acetate. Both vitamins were in the injectable form and were injected into the right hip of the cattle. Cows were weighed at the times they received the vitamin injections.

A total of 212 cows were used in the experiment the first year, 193 the second year and 228 the third year, and average of 211 cows per year. As a yearly average, there were 26 cows per lot, 105 cows per treatment in the trace mineral vs. no trace mineral comparison, and 53 cows per treatment in the vitamin comparisons.

All cows used in the experiment had been moved to the experimental location on the north side of Lake Carl Blackwell, from either the south side of Lake Carl Blackwell or the Ft. Reno Livestock Experiment Station at El Reno, Oklahoma. The cows had spent the previous winter and summer at the experimental location and had been pasture bred prior to the initiation of the experiment.

Each fall the cows were randomly assigned to lots and treatments. The cows remained in the assigned lots throughout the subsequent calving and breeding seasons, until reassignment the following fall. Each lot was maintained in one separate pasture throughout the year, without rotation among pastures.

Cows were pasture mated May 1 to August 1 each year, with one bull to each lot of cows. The majority of the calves were born in February and March. All cows (and bulls) were Angus and were in the progeny test herd of the station. The cows ranged from 2 to 12 years of age.

The cattle were maintained 15 miles west of Stillwater, Oklahoma, and were kept under range conditions throughout the experiment. Pastures at the Lake Carl Blackwell range consist mostly of native grasses; the climax grasses are big and little bluestem, Indian and switch grass. The area consists of both virgin pastures and previously cultivated fields.

During the winter the cows were allowed to graze dry winter grass and were fed soybean meal at the rate of 2 lb. per head daily (fed on alternate days at twice the daily rate) from November 15 to April 15. The soybean meal was believed to contain 44% crude protein, but chemical analysis showed that the product fed during the third winter contained 37% protein. Meals fed the first and second winters were not analyzed. Prairie hay was fed at a level of 10 lb. per head daily starting about January 20 and ending April 15. The cows had access at all times to a mineral mix containing 50% dicalcium phosphate and 50% salt.

Composite samples of prairie hay and soybean meal representing the entire third-winter supply were obtained, and composite hand-picked grass samples from three areas of each pasture were taken February 1 and March 30, 1966. Pasture samples taken in late winter (February and March) should represent forage of the lowest nutritive value for the entire year. These samples were ashed at 600°C for 12 hours, dissolved

TABLE III

MINERAL COMPOSITION OF FEEDS

Feed	Element										
	Ca[a]	Mg[a]	P[a]	Cu[a]	Zn[a]	Na[a]	K[a]	Fe[a]	Mn[a]	I[b]	Co[b]
	%	%	%	ppm	ppm	%	%	ppm	ppm	ppm	ppm
Prairie Hay	.457	.170	.048	1.90	38.3	.053	.533	199.6	18.05	0.10	0.14
Grass (2-1-66)	.341	.082	.033	2.31	43.1	.023	.084	60.6	27.92	0.10	0.14
Grass (3-30-66)	.302	.066	.026	1.73	35.7	.017	.077	48.0	21.78	0.10	0.14
Soybean meal	.364	.317	.588	1.81	50.57	.060	2.000	175.39	14.44	0.13	0.10
Soybean meal with trace minerals	.454	.317	.537	2.46	154.87	.046	1.850	275.51	50.58	2.63	1.35

a - Values based on laboratory analysis of samples of feeds used during the third year of the experiment.

b - Values based on Poultry Nutrition manual compiled by staff of Poultry Science Department at Oklahoma State University.

in 4N hydrochloric acid and then aliquots were taken for analysis for calcium, magnesium, potassium, copper, zinc, sodium, iron and manganese by atomic absorption spectrophotometry. Phosphorus was determined by the method given by Fiske and Suba Row (1925). Mineral composition of the feeds is indicated in Table III. Dry matter, ash, crude protein, fat, fiber and N.F.E. were also determined on the feedstuffs by the method given by A.O.A.C. (1960). Proximate composition of the feeds is shown in Table IV.

A random sample of 10 cows from each vitamin treatment group was bled during the third year. Blood samples were taken in December, 1965; February, 1966; April, 1966; and June, 1966. Blood samples were taken by jugular puncture and were collected in tubes containing sodium citrate as an anticoagulant. All samples were kept under refrigeration until analyzed. The samples were centrifuged and the plasma collected for analysis of calcium, copper, zinc, potassium, and magnesium by atomic absorption spectrophotometry. Phosphorus was determined by the method given by Fiske and Suba Row (1925).

The following data were obtained for each calf: birth date, birth weight, sex, weaning weight, condition score at weaning, and conformation score at weaning. Condition and conformation scores represent an average of three scores estimated by three different persons. Calves were weaned in October at an average age of 202 days.

The weaning weights of the calves were adjusted for sex of calf, age of dam and to a constant age of 205 days. The correction factors used for age of dam were 1.15 for 2-year old cows, 1.10 for 3-year old cows, and 1.05 for 4-year old cows. No correction factors were used for cows over 4 years of age. The correction factor for heifer calves

TABLE IV

PROXIMATE COMPOSITION OF FEEDS

	Dry matter	Ash	Crude protein	Fat	Fiber	N.F.E.
	%	%	%	%	%	%
Hay[a]	90.6	6.8	4.2	1.9	27.5	50.2
Grass (2-1-66)	94.1	10.6	3.2	1.4	30.3	48.6
Grass (3-30-66)	94.7	8.7	3.5	1.6	31.1	49.8
Soybean meal[a]	90.6	5.7	36.7	0.5	5.8	41.9
Soybean meal with trace mineral[a]	90.7	5.8	37.2	0.4	4.4	42.9

a - Based on composite sample of entire third-winter supply.

was 1.05 and for bull calves 0.95. The formula used for calculating the adjusted 205-day weight is as follows:

$$\text{205-day wt.} = \frac{\text{Actual wt.} - \text{birth wt.}}{\text{age in days}} \times 205 + \text{birth wt.}$$

X the adjustment factor(s).

Conception rate and calf survival were calculated for each treatment. The conception rate for each breeding season was estimated by the calving performance of the cows, the subsequent calving season, and calculated by the formula:

$$\frac{\text{No. of cows that calves}}{\text{No. of cows in treatment group at time of calving}} \times 100 = \%\ \text{conception.}$$

Calf survival was calculated by the formula:

$$\frac{\text{No. of calves weaned}}{\text{No. of cows that calved}} \times 100 = \%\ \text{calf survival.}$$

Calf survival and conception rate were statistically analyzed by the method of binomial probability and all other data were statistically analyzed by the Abbreviated Doolittle Method, as outlined by Steel and Torrie (1960).

RESULTS AND DISCUSSION

Production Data

Conception Rate

The conception rates for the treatment groups are presented in Table V. The conception rate of the cows was not significantly ($P > .05$) influenced by the injection of vitamin A and/or E or by supplementation with trace minerals.

The vitamin A injected group had the highest conception rate for the first two years of the experiment and the vitamin E group had the lowest conception rate for this period. The third year the cows which did not receive any vitamins had the highest conception rate and the cows which received both vitamin A and E had the lowest conception rate. With the exception of the third year, the cows which received both vitamin A and E had a conception rate which was intermediate between those receiving vitamin A and those receiving vitamin E. The injection of vitamin E seemed to decrease the conception rate when it was injected with vitamin A or when it was used alone. The decrease in response to vitamin A when vitamin E was also injected was reported by Chapman et al. (1964) in growth rate of steers.

Calf Survival

The percent calf survival for each treatment group is given in

TABLE V

AFFECT OF VITAMIN AND TRACE MINERAL SUPPLEMENTATION ON CONCEPTION RATE OF COWS

	Winter 1963-64			Winter 1964-65			Winter 1965-66			3-Year Average		
	No.[1] Cows	No.[2] Calves	%[3]	No. Cows	No. Calves	%	No. Cows	No. Calves	%	No. Cows	No. Calves	%
No Vitamins	59	53	89.8	56	52	92.8	58	58	100.0	173	163	94.2
Vitamin A	53	50	94.3	48	46	95.8	55	54	98.1	156	150	96.2
Vitamin E	50	41	82.0	48	41	85.4	57	55	96.4	155	137	88.4
Vitamin A+E	49	42	85.7	48	45	93.7	58	55	94.8	155	143	91.6
No. TM[4]	106	90	84.9	100	90	90.0	136	134	98.5	342	314	91.8
TM[5]	105	96	91.4	100	94	94.0	92	88	95.6	297	278	93.6

1 - Number of cows in treatment group at time of calving.

2 - Number of calves that were born, either dead or alive. Aborted calves are included.

3 - Number of calves divided by number of cows.

4 - No supplemental trace minerals.

5 - Supplemental trace minerals.

Table VI. The percent calf survival was not significantly influenced by treatment.

The trends noted in conception rate were not noted in percent calf survival. None of the vitamin treatments (with the exception of the first year) resulted in a percent calf survival that was higher than the group which did not receive any vitamins. The trace mineral supplemented group had a lower percent calf survival than the unsupplemented cows for the 3-year average, although the difference was not significant. The reverse was true in the case of conception rate, with the trace mineral supplemented group having the highest conception rate.

Birth Date of Calves

The analysis of variance for the birth date of the calves is given in Table VII. The means for the treatment groups are shown in Table VIII.

There was a significant interaction between vitamin A and E on birth date of the calves. A combination of vitamin A and E resulted in earlier calves than either Vitamin A or E used alone. These results suggest that either vitamin A or E, used separately, delayed conception and the use of the second vitamin alleviated the delaying effect. It is also noted that the cows which received vitamin A calved 2 days later than those which did not receive any vitamins. These results do not agree with those reported by Melton and Ellis (1965), who observed that cows which had been injected with vitamin A calved 5 days earlier.

Birth Weight of Calves

Table IX shows the analysis of variance for birth weight and Table

TABLE VI

AFFECT OF VITAMIN AND TRACE MINERAL SUPPLEMENTATION ON CALF SURVIVAL

	Winter 1963-64			Winter 1964-65			Winter 1965-66			3-Year Average		
	No.[1] Cows	No.[2] Calves	%[3]	No. Cows	No. Calves	%	No. Cows	No. Calves	%	No. Cows	No. Calves	%
No Vitamins	50	40	80.0	52	50	96.1	58	57	98.3	160	147	91.9
Vitamin A	51	44	96.3	46	41	89.1	55	52	94.5	152	137	90.1
Vitamin E	45	40	88.9	41	38	92.7	57	54	94.7	143	132	92.3
Vitamin A+E	40	38	95.0	45	39	86.7	58	57	98.2	143	134	93.7
No TM[4]	92	80	87.0	95	86	90.5	136	133	97.7	323	299	92.6
TM[5]	94	82	87.2	89	82	92.1	92	87	94.5	275	251	91.3

1 - Number of cows that calved.

2 - Number of calves that were weaned.

3 - Number of calves divided by number of cows.

4 - No supplemental trace minerals.

5 - Supplemental trace minerals.

TABLE VII

ANALYSIS OF VARIANCE FOR BIRTH DATE

Source of Variation	df	MS	F
Total	524		
Location	1	66.8106	0.166
Trace minerals	1	121.8384	0.303
Year	2	6733.1008	16.760**
Vitamin A	1	499.4274	1.243
Vitamin E	1	453.1994	1.128
Vit. A X vit. E	1	3365.7309	8.378*
T.M. X vit. A	1	707.5319	1.761
T.M. X vit. E	1	2.2654	0.005
T.M. X vit. A X vit. E	1	71.8473	0.179
Error	6	401.7300	
Residual	509	1372.4700	

* (P<.05)

** (P<.01)

TABLE VIII

AFFECT OF VITAMIN AND TRACE MINERAL SUPPLEMENTATION ON BIRTH DATE

Treatment	Winter 1963-64		Winter 1964-65		Winter 1965-66		3-Year Average	
	No. Calves[a]	Birth Date	No. Calves	Birth Date	No. Calves	Birth Date	No. Calves	Birth Date
No Vitamins	36	March 14[b]	50	March 1	57	March 4	143	March 6
Vitamin A	41	March 16	41	March 4	52	March 5	134	March 8
Vitamin E	39	March 24	38	March 12	54	March 4	131	March 13
Vitamin A+E	38	March 11	39	Feb. 26	57	March 5	134	March 5
No TM[c]	80	March 21	86	March 3	133	March 4	299	March 9
TM[d]	74	March 19	82	March 4	87	March 4	243	March 8

[a] - Number of calves that were weaned.

[b] - Standard error of the mean was ±2.1.

[c] - No supplemental trace minerals.

[d] - Supplemental trace minerals.

TABLE IX

ANALYSIS OF VARIANCE FOR BIRTH WEIGHT

Source of Variation	df	MS	F
Total	524		
Location	1	426.8244	9.789*
Trace Mineral	1	23.4035	0.537
Year	2	2206.2323	50.602**
Vitamin A	1	31.9641	0.733
Vitamin E	1	33.2653	0.763
Vit. A X vit. E	1	151.7169	3.480
T.M. X vit. A	1	1.4467	0.033
T.M. X vit. E	1	24.4850	0.561
T.M. X vit. A X vit E	1	50.1119	1.149
Error	6	43.6000	
Residual	509	136.0836	

* $(P<.05)$

** $(P<.01)$

X gives the mean birth weight for each treatment group. The treatments imposed on the cows did not significantly $(P>.05)$ influence the birth weight of calves. Differences in birth weight of the calves among the treatment groups were very small and the trends previously noted were not apparent.

<u>205-Day Adjusted Weaning Weight</u>

The analysis of variance for the 205-day adjusted weaning weight is given in Table XI. Table XII shows the means for the treatment groups. The 205-day weaning weight was not significantly influenced by treatment. The calves from the cows which received vitamin E had

TABLE X

AFFECT OF VITAMIN AND TRACE MINERAL SUPPLEMENTATION ON BIRTH WEIGHT

Treatment	Winter 1963-64		Winter 1964-65		Winter 1965-66		3-Year Average	
	No. Calves[a]	Birth Weight	No. Calves	Birth Weight	No. Calves	Birth Weight	No. Calves	Birth Weight
No Vitamins	36	59[b]	50	59	57	67	143	63
Vitamin A	41	61	41	61	52	66	134	63
Vitamin E	39	60	38	59	54	67	131	62
Vitamin A+E	38	59	39	61	57	64	134	61
No TM[c]	80	60	86	61	133	66	299	62
TM[d]	74	60	82	60	87	66	243	62

a - Number of calves that were weaned.

b - Standard error of the mean was ±1.3.

c - No supplemental trace minerals.

d - Supplemental trace minerals.

TABLE XI

ANALYSIS OF VARIANCE FOR 205-DAY ADJUSTED WEANING WEIGHT

Source of Variation	df	MS	F
Total	524		
Location	1	71708.82	33.932**
Trace mineral	1	813.62	0.385
Year	2	29668.67	14.039**
Vitamin A	1	62.50	0.029
Vitamin E	1	3331.27	1.576
Vit. A X vit. E	1	31.80	0.015
T.M. X vit. A	1	562.97	0.266
T.M. X vit. E	1	3344.00	1.583
T.M. X vit. A X vit. E	1	4375.04	2.070
Error	6	2113.33	
Residual	508	4068.29	

** (P<.01)

TABLE XII

AFFECT OF VITAMIN AND TRACE MINERAL SUPPLEMENTATION ON 205-DAY ADJUSTED WEANING WEIGHT

Treatment	Winter 1963-64		Winter 1964-65		Winter 1965-66		3-Year Average	
	No. Calves[a]	205-Day Weight	No. Calves	205-Day Weight	No. Calves	205-Day Weight	No. Calves	205-Day Weight
No Vitamins	36	444[b]	50	447	57	462	143	451
Vitamin A	41	432	41	453	52	463	134	449
Vitamin E	39	430	38	437	54	462	131	443
Vitamin A+E	38	430	39	456	57	452	134	446
No TM[c]	80	433	86	448	133	462	299	448
TM[d]	74	435	82	448	87	455	243	446

[a] - Number of calves that were weaned.

[b] - Standard error of the mean was ±6.4.

[c] - No supplemental trace minerals.

[d] - Supplemental trace minerals.

the lowest weaning weight for the 3-year average, and the calves from the cows which received both vitamin A and E had a weaning weight which was intermediate between those which received vitamin A and those which received E. Although differences in weaning weight were small, this is the same pattern that was noted in the conception rate of the cows.

These results do not agree with those reported by Melton and Ellis (1965) who noted a 23 lb. increase in weaning weight in calves from dams which had been injected with vitamin A. In previous work at this station, also at the Lake Carl Blackwell Range, Totusek (1965) noted a 14 lb. advantage in weight of calves at 112 days of age from cows which had been injected with vitamin A.

Average Daily Gain of Calves

Table XIII shows the analysis of variance for average daily gain of the calves. The means for the treatment groups are given in Table XIV.

The treatments imposed on the cows did not significantly influence the average daily gain of their calves. However, there was some evidence ($P<.06$) of an interaction among trace minerals, vitamin A and vitamin E. Since this interaction was not noted in the 205-day adjusted weights, the difference in sex of calves and in the age of the cows and calves could have caused this interaction.

Weaning Grade and Condition

The analysis of variance for weaning grade and weaning condition are given in Tables XV and XVII and treatment means for weaning grade and weaning condition are shown in Tables XVI and XVIII, respectively.

TABLE XIII

ANALYSIS OF VARIANCE FOR AVERAGE DAILY GAIN OF CALVES

Source of Variation	df	MS	F
Total	524		
Location	1	1.3436	28.168**
Trace mineral	1	0.00000008	0.000001
Year	2	1.2473	26.149**
Vitamin A	1	0.0201	0.421
Vitamin E	1	0.0499	1.047
Vit. A X vit. E	1	0.0013	0.027
T.M. X vit. A	1	0.0097	0.204
T.M. X vit. E	1	0.0243	0.509
T.M. X vit. A X vit. E	1	0.2484	5.208
Error	6	0.0477	
Residual	509		

** (P<.01)

TABLE XIV

AFFECT OF VITAMIN AND TRACE MINERAL SUPPLEMENTATION ON AVERAGE DAILY GAIN OF CALVES

Treatment	Winter 1963-64		Winter 1964-65		Winter 1965-66		3-Year Average	
	No. Calves[a]	ADG	No. Calves	ADG	No. Calves	ADG	No. Calves	ADG
No Vitamins	36	1.74[b]	50	1.86	57	1.87	143	1.82
Vitamin A	41	1.71	41	1.90	52	1.88	134	1.83
Vitamin E	39	1.71	38	1.82	54	1.87	131	1.80
Vitamin A+E	38	1.70	39	1.90	57	1.84	134	1.81
No TM[c]	80	1.72	86	1.87	133	1.87	299	1.82
TM[d]	74	1.72	82	1.87	87	1.86	243	1.82

[a] – Number of calves that were weaned.

[b] – Standard error of the mean was 0.09.

[c] – No supplemental trace minerals

[d] – Supplemental trace minerals.

TABLE XV

ANALYSIS OF VARIANCE FOR WEANING GRADE OF CALVES

Source of Variation	df	MS	F
Total	524		
Location	1	0.0443	0.033
Trace mineral	1	0.2573	0.191
Year	2	404.6044	300.152**
Vitamin A	1	3.3741	2.503
Vitamin E	1	1.4069	1.044
Vit. A X vit. E	1	0.0071	0.005
T.M. X vit. A	1	1.9749	1.465
T.M. X vit. E	1	0.1172	0.087
T.M. X vit. A X vit. E	1	0.2559	0.190
Error	6	1.3480	
Residual	509	1.6186	

** (P<.01)

TABLE XVI

AFFECT OF VITAMIN AND TRACE MINERAL SUPPLEMENTATION
ON WEANING GRADE OF CALVES

Treatment	Winter 1963-64		Winter 1964-65		Winter 1965-66		3-Year Average	
	No. Calves[a]	Weaning Grade	No. Calves	Weaning Grade	No. Calves	Weaning Grade	No. Calves	Weaning Grade
No Vitamins	36	9.9[b]	50	12.7	57	12.5	143	11.7
Vitamin A	41	9.9	41	12.7	52	12.5	134	11.8
Vitamin E	39	9.6	38	12.3	54	12.6	131	11.5
Vitamin A+E	38	9.8	39	12.6	57	12.6	134	11.7
No TM[c]	80	9.7	86	12.6	133	12.7	299	11.7
TM[d]	74	9.9	82	12.6	87	12.6	243	11.7

[a] - Number of calves that were weaned.

[b] - Standard error of the mean was ±0.14.

[c] - No supplemental trace minerals.

[d] - Supplemental trace minerals.

TABLE XVII

ANALYSIS OF VARIANCE FOR WEANING CONDITION OF CALVES

Source of Variation	df	MS	F
Total	524		
Location	1	0.6772	0.869
Trace minerals	1	0.4021	0.516
Year	2	389.7887	500.371**
Vitamin A	1	2.0356	2.613
Vitamin E	1	4.0944	5.256
Vit. A X vit. E	1	2.9523	3.790
T.M. X vit. A	1	0.2709	0.348
T.M. X vit. E	1	0.1498	0.192
T.M. X vit. A X vit. E	1	0.0300	0.038
Error	6	0.7790	
Residual	509	1.3696	

** $(P<.01)$

TABLE XVIII

AFFECT OF VITAMIN AND TRACE MINERAL SUPPLEMENTATION ON WEANING CONDITION OF CALVES

Treatment	Winter 1963-64		Winter 1964-65		Winter 1965-66		3-Year Average	
	No. Calves[a]	Weaning Cond.	No. Calves	Weaning Cond.	No. Calves	Weaning Cond.	No. Calves	Weaning Cond.
No Vitamins	36	10.0[b]	50	12.6	57	12.6	143	11.7
Vitamin A	41	9.8	41	12.5	52	12.8	134	11.7
Vitamin E	39	9.6	38	12.1	54	12.5	131	11.4
Vitamin A+E	38	9.9	39	12.5	57	12.6	134	11.7
No TM[c]	80	9.7	86	12.5	133	12.6	299	11.6
TM[d]	74	9.9	82	12.4	87	12.6	243	11.6

[a] - Number of calves that were weaned with complete data obtained.

[b] - Standard error of the mean was ±0.11.

[c] - No supplemental trace minerals.

[d] - Supplemental trace minerals.

The weaning grade of the calves was not significantly influenced by treatment. The weaning grade for the calves from the cows injected with vitamin E was slightly lower than the other three vitamin treated groups.

The weaning condition of the calves was not significantly influenced by the treatments imposed on their dams. However, there was some evidence ($P<.06$) that the injection of vitamin E to the cows lowered the weaning condition of the calves. This slightly lowered response to vitamin E injections was noted in other measurements previously discussed. Both the 205-day adjusted weight and the average daily gain of the calves from the cows which received vitamin E were slightly lower than the other vitamin groups.

Winter Weight Changes of the Cows

The analysis of variance and the treatment means for the winter weight changes of the cows are given in Tables XIX and XX, respectively.

The winter weight loss patterns were quite similar for the different treatment groups and were not significantly influenced by treatment. The decrease in response to vitamin E was not noted in the winter weight loss of the cows. Previous work at this station produced similar results (Totusek, 1965).

Rainfall amounts and average temperatures for the three winters are given in Table XXI. The estimated intake of carotene and alpha-tocopherol is given in Tables XXII and XXIII, respectively.

During the three years of the experiment, the rainfall amounts and mean temperatures were quite close to the normal values. Since there

TABLE XIX

ANALYSIS OF VARIANCE FOR WINTER WEIGHT CHANGE OF COWS

Source of Variation	df	MS	F
Total	524		
Location	1	26068.62	1.707
Trace mineral	1	6884.52	0.451
Year	2	474798.18	31.099**
Vitamin A	1	1622.21	0.106
Vitamin E	1	11808.02	0.773
Vit. A X vit. E	1	1067.31	0.070
T.M. X vit. A	1	5179.09	0.339
T.M. X vit. E	1	1352.11	0.088
T.M. X vit. A X vit. E	1	48.74	0.003
Error	6	15266.85	
Residual	509	11619.69	

** (P<.01)

TABLE XX

AFFECT OF VITAMIN AND TRACE MINERAL SUPPLEMENTATION ON WINTER WEIGHT CHANGES OF COWS

Treatment	Winter 1963-64		Winter 1964-65		Winter 1965-66		3-Year Average	
	No. Cows	Mean Weight Change	No. Cows	Mean Weight Change	No. Cows	Mean Weight Change	No. Cows	Mean Weight Change
No Vitamins	59	-117	48	-14	55	-65	162	-65
Vitamin A	54	-30	46	-8	57	-70	157	-36
Vitamin E	50	-102	46	-6	58	-38	154	-48
Vitamin A+E	49	-150	53	-12	58	-50	160	-71
No TM[a]	106	-110	97	-21	136	-45	339	-59
TM[b]	106	-141	96	1	92	-73	294	-71

[a] - No supplemental trace minerals.

[b] - Supplemental trace minerals.

TABLE XXI

TEMPERATURES AND RAINFALL DURING THE EXPERIMENT, COMPARED TO THE NORMAL

Item	MONTH						
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Normal Temperature (F^o)	74.2[1]	63.5	49.1	40.8	37.9	42.2	49.6
Winter 1963-64	74.9	69.8	51.0	32.6	41.5	39.5	47.8
Winter 1964-65	72.9	60.3	52.9	38.7	40.4	40.4	40.7
Winter 1965-66	63.6	60.8	55.0	47.0	33.2	38.6	51.6
Normal Rainfall (in.)	3.38[2]	2.78	1.85	1.34	1.16	1.35	1.86
Winter 1963-64	3.03	2.07	1.69	0.19	0.54	1.61	1.02
Winter 1964-65	2.43	0.54	5.28	0.64	0.99	0.71	1.38
Winter 1965-66	6.50	0.52	0.04	2.26	0.18	1.48	0.17

[1] - Mean monthly temperature.

[2] - Total monthly rainfall amount.

TABLE XXII

ESTIMATED CAROTENE INTAKE OF COWS

Feed	Carotene Content[a]	Estimated Carotene Intake Per Head Daily		
		Early Winter	Late Winter	Spring
	mg./lb.	mg./lb.	mg./lb.	mg./lb.
Pasture[b]				
Early Winter	6.3	120.8		
Late Winter	2.2		13.2	
Spring	184.8			2956.8
Prairie Hay[c]	5.9		59.0	
Soybean Meal	0.0			
Total		120.8	72.2	2956.8
Requirement[d]		45.0	45.0	45.0

a - Values based on previous analysis of feeds produced on same range area as used in this experiment. From Van Arsdell (1952), Ph.D Thesis, Okla. Agr. and Mech. Col., Stillwater, Okla.

b - Based on 16 lb. per head daily with no hay and 6 lb. per head daily with 10 lb. of hay.

c - Hay fed from January 20 to April 15.

d - Requirements from N.R.C. 1963. Nutrient Requirements of Domestic Animals, No. 4. Nutrient Requirements of Beef Cattle. Nat. Res. Coun., Washington, D.C.

TABLE XXIII

ESTIMATED DIETARY ALPHA-TOCOPHEROL INTAKE OF COWS

Feed	Alpha-Tocopherol Content[a]	Estimated Alpha-Tocopherol Intake per Head Daily		
		Early Winter	Late Winter	Spring
	mg./lb.	mg.	mg.	mg.
Pasture[b]				
Early Winter	16	96		
Late Winter	4		24	
Spring	30			480
Prairie Hay[c]	9		90	
Soybean Meal[d]	8.5		17	
Total		96	131	480
Requirement[e]		30	30	30

[a] - Values based on estimates from vitamin E for Farm Animals, (1965). Hoffman-LaRoche Inc., Nutley, New Jersey.

[b] - Based on 16 lb. per head daily with no hay and 6 lb. per head daily with 10 lb. of hay.

[c] - Hay fed from January 20 to April 15.

[d] - Based on 2 lb. per head daily.

[e] - Requirements from N.R.C. 1963. Nutrient Requirements of Domestic Animals, No. 4, Nutrient Requirements of Beef Cattle. Nat. Res. Coun., Washington, D.C.

were no extreme weather conditions during the experiment, there was probably enough green grass along the sheltered areas of the pastures to supply the animals with appreciable amounts of carotene through the winter. Even in November the pasture furnished about twice the amount of carotene that is required. Also, the feeding of 10 lb. of prairie hay alone furnished enough carotene to exceed the carotene requirement. These several reasons suggest why no benefit from vitamin A injections was observed.

Table XXIV shows the estimated intake of trace minerals. Calculations showed that feeds the cows consumed supplied sufficient quantities of trace minerals to meet the daily requirements indicated by the National Research Council. The pasture alone met or exceeded the minimum daily requirements for each of the trace minerals. These results suggest that trace mineral intakes above presently recommended levels are of no value.

Blood Plasma Composition

A summary of the blood plasma mineral levels is presented in Table XXV. Figures 1 to 6 graphically illustrate the blood plasma levels of the minerals at the four bleeding times.

The plasma levels of phosphorus, copper, and zinc for the cows which received supplemental trace minerals did not differ significantly from the plasma levels of the control group. The plasma levels of these minerals were considered to be normal and were similar to the values obtained by other workers (Van Arsdell, 1952; Long, 1952; and Erlinger, 1968).

The plasma calcium content for the two groups did not differ

TABLE XXIV

ESTIMATED INTAKE OF TRACE MINERALS OF COWS

Element	Amount Supplied Per Head Daily					Estimated Daily Intake Per Cow				Daily Requirement Per Cow[a]
	Pasture		Prairie Hay[b]	Soybean Meal[c]	TM	No TM		TM		
	16 lb.	6 lb.				Without Hay	With Hay	Without Hay	With Hay	
	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Zinc	322	120	174	46	95	368	340	463	435	244
Iron	440	165	270	159	114	599	594	713	708	200
Manganese	180	68	82	13	79	193	163	272	242	54-90
Copper	32	12	9	2	11	34	23	45	34	32-41
Iodine	.72	.27	.45	.12	2.3	.84	.84	3.14	3.14	.40-.80
Cobalt	1.02	.39	.64	.09	1.13	1.11	1.12	2.24	2.25	0.6-1.0

[a] - Requirements for Mn, Cu, I and Co based on N.R.C. 1963. Nutrient Requirements of Domestic Animals, No. 4. Nutrient Requirements of beef cattle. Nat. Res. Coun., Washington, D.C.

[b] - Hay was fed at a level of 10 lb. per head daily from January 20 to April 15.

[c] - Soybean meal was fed at a level of 2 lb. per head (fed on alternate days at twice the daily rate) daily from November 15 to April 15.

TABLE XXV

AFFECT OF TRACE MINERAL SUPPLEMENTATION ON BLOOD PLASMA LEVELS OF COWS

Treatment	Element					
	P SE[e]	Ca SE	Mg SE	Cu SE	Zn SE	K SE
	mg.%	mg.%	mg.%	ppm	ppm	mg.%
			December 16, 1965			
No TM[a]	4.14±31	6.13±19	2.05±05	1.35±02	0.66±03	19.09±31
TM[b]	3.67±30	6.55±15	2.01±07	1.38±03	0.72±04	19.58±53
			February 3, 1966			
No TM	4.65±19	11.24±12	2.54±05	1.05±03	0.83±03	26.87±70[d]
TM	4.43±20	10.95±12	2.46±14	0.98±09	0.80±15	24.58±1.53
			April 30, 1966			
No TM	2.96±28	11.27±10	2.72±04[c]	1.53±08	1.05±06	17.74±43
TM	3.13±83	11.03±16	2.55±04	1.46±05	0.96±06	18.34±65
			June 17, 1966			
No TM	3.67±29	10.34±16	2.41±02[d]	0.86±04	0.85±03	25.19±58
TM	4.21±39	10.56±13	2.31±06	0.90±06	0.84±06	24.26±66

[a] - No supplemental trace minerals.

[b] - Supplemental trace minerals.

[c] - ($P<.01$).

[d] - ($P<.05$).

[e] - Standard error of the treatment means.

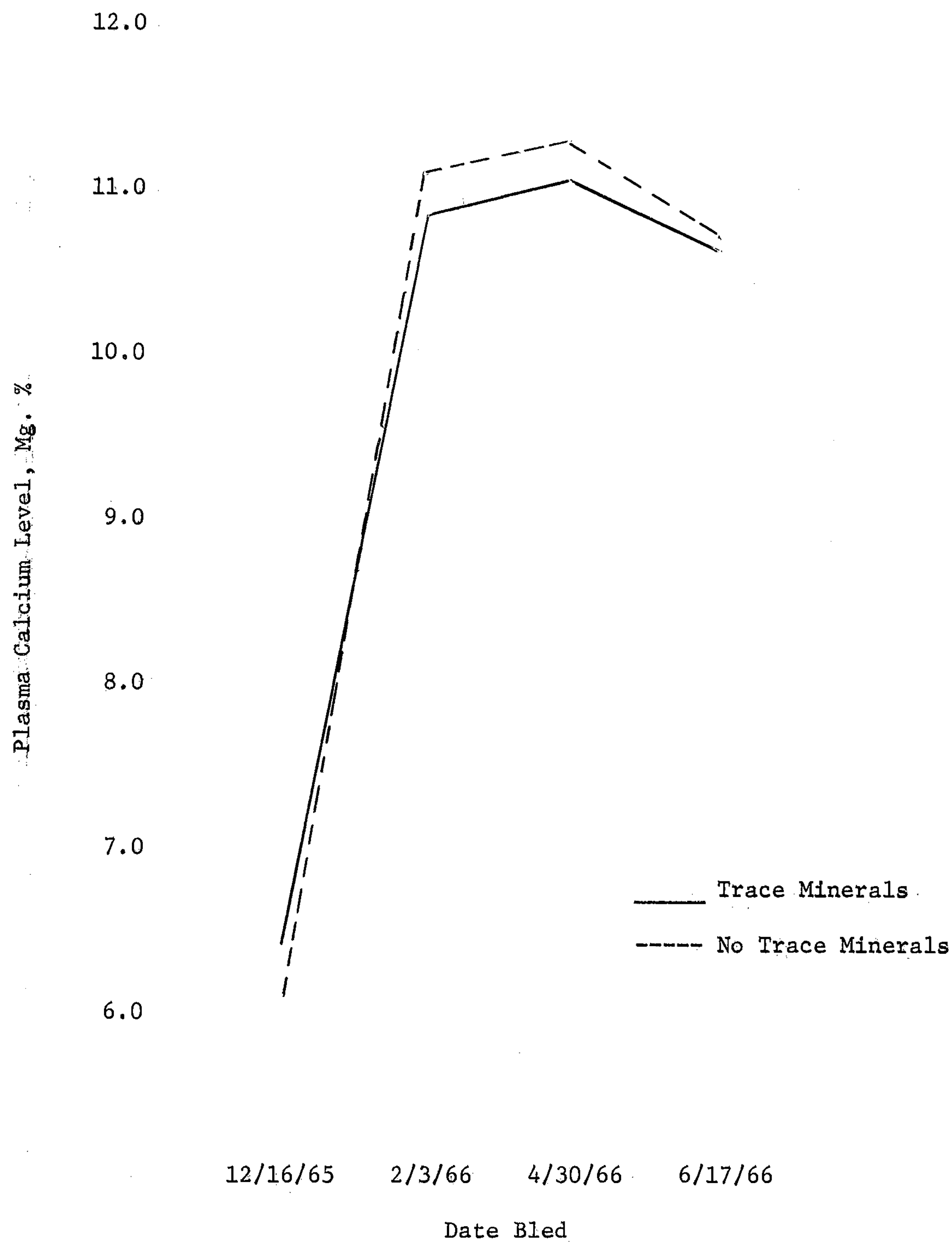

Figure 1. Influence of Trace Minerals on Plasma Calcium Level

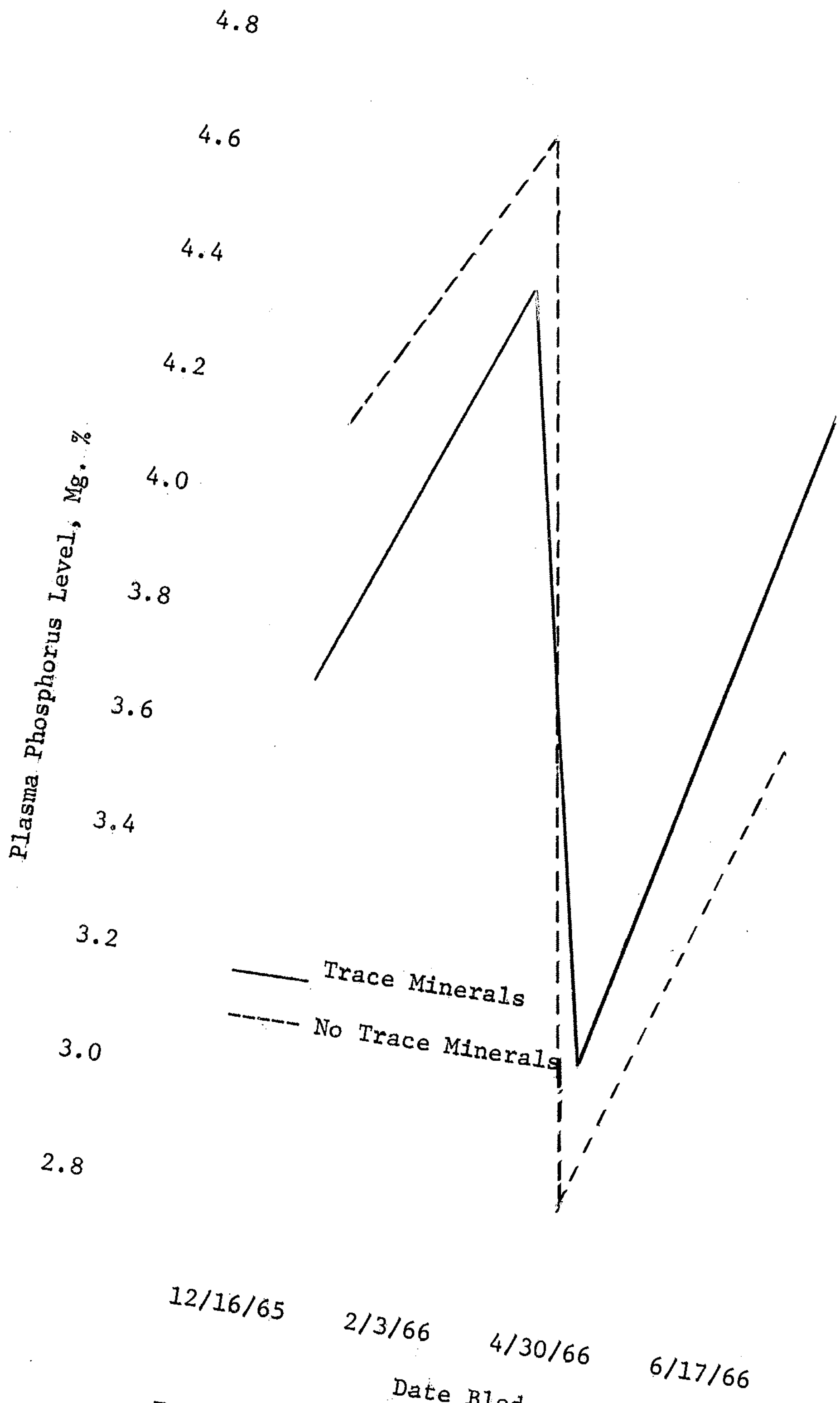

Figure 2. Influence of Trace Minerals on Plasma Phosphorus Level

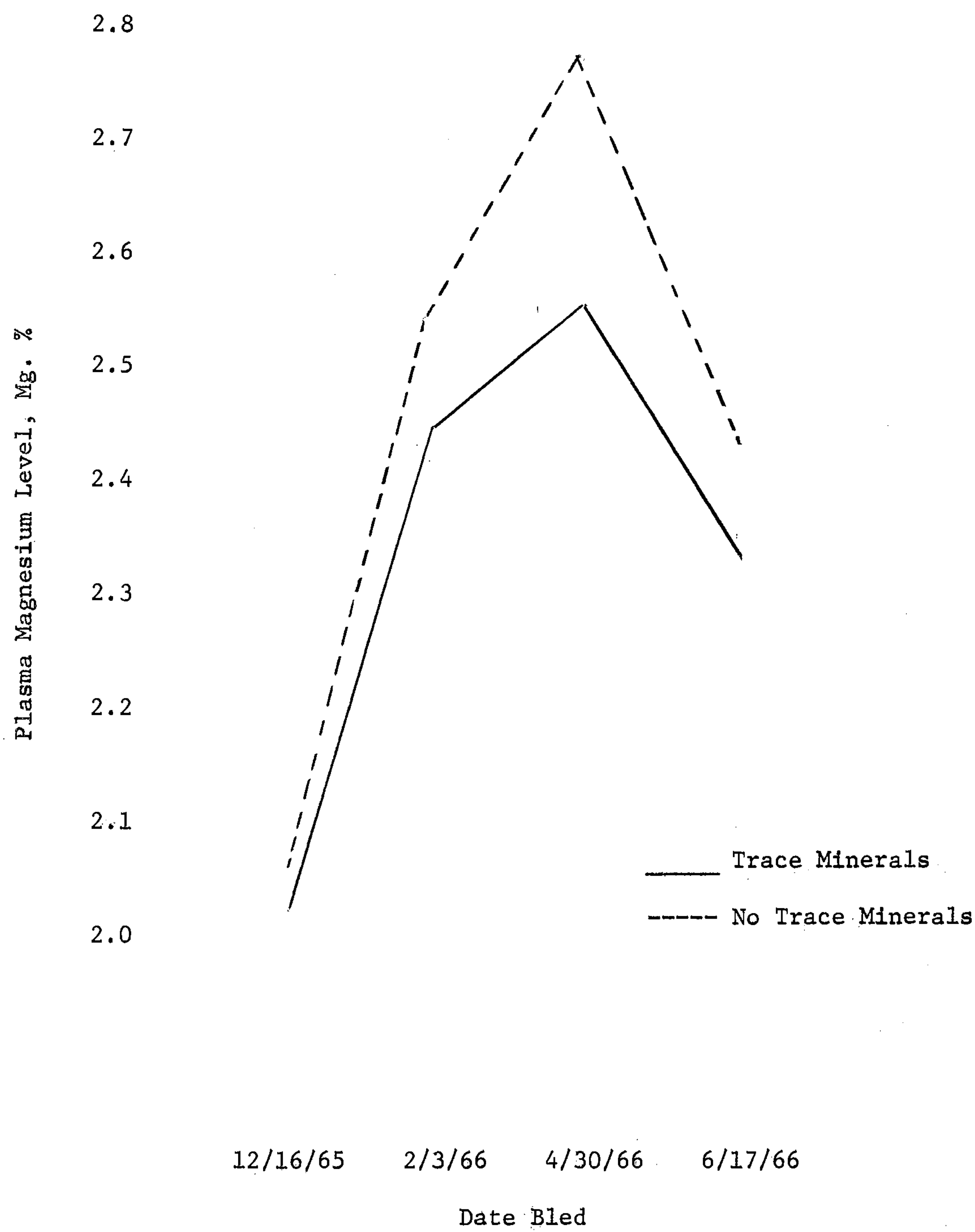

Figure 3. Influence of Trace Minerals on Plasma Magnesium Level

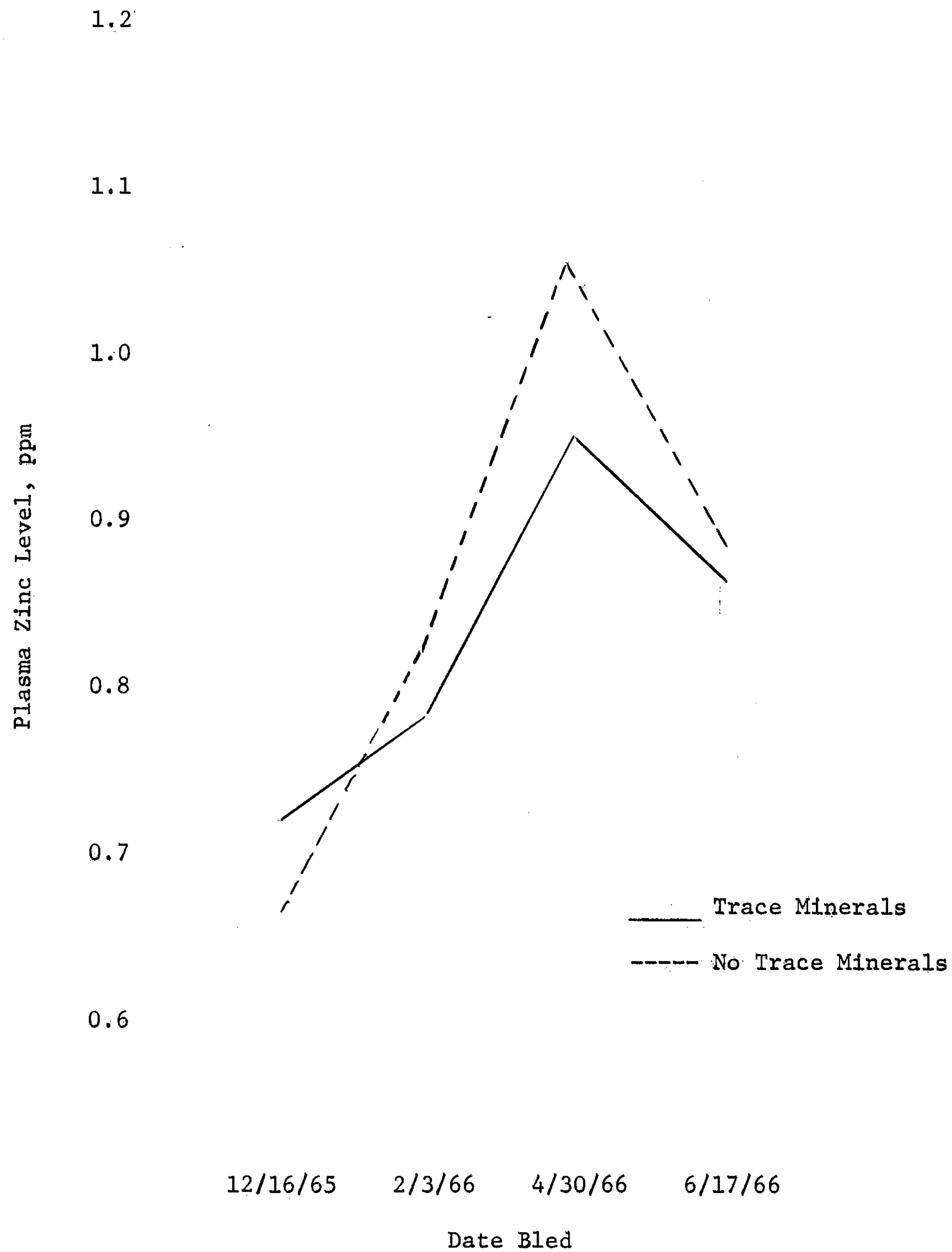

Figure 4. Influence of Trace Minerals on Plasma Zinc Level

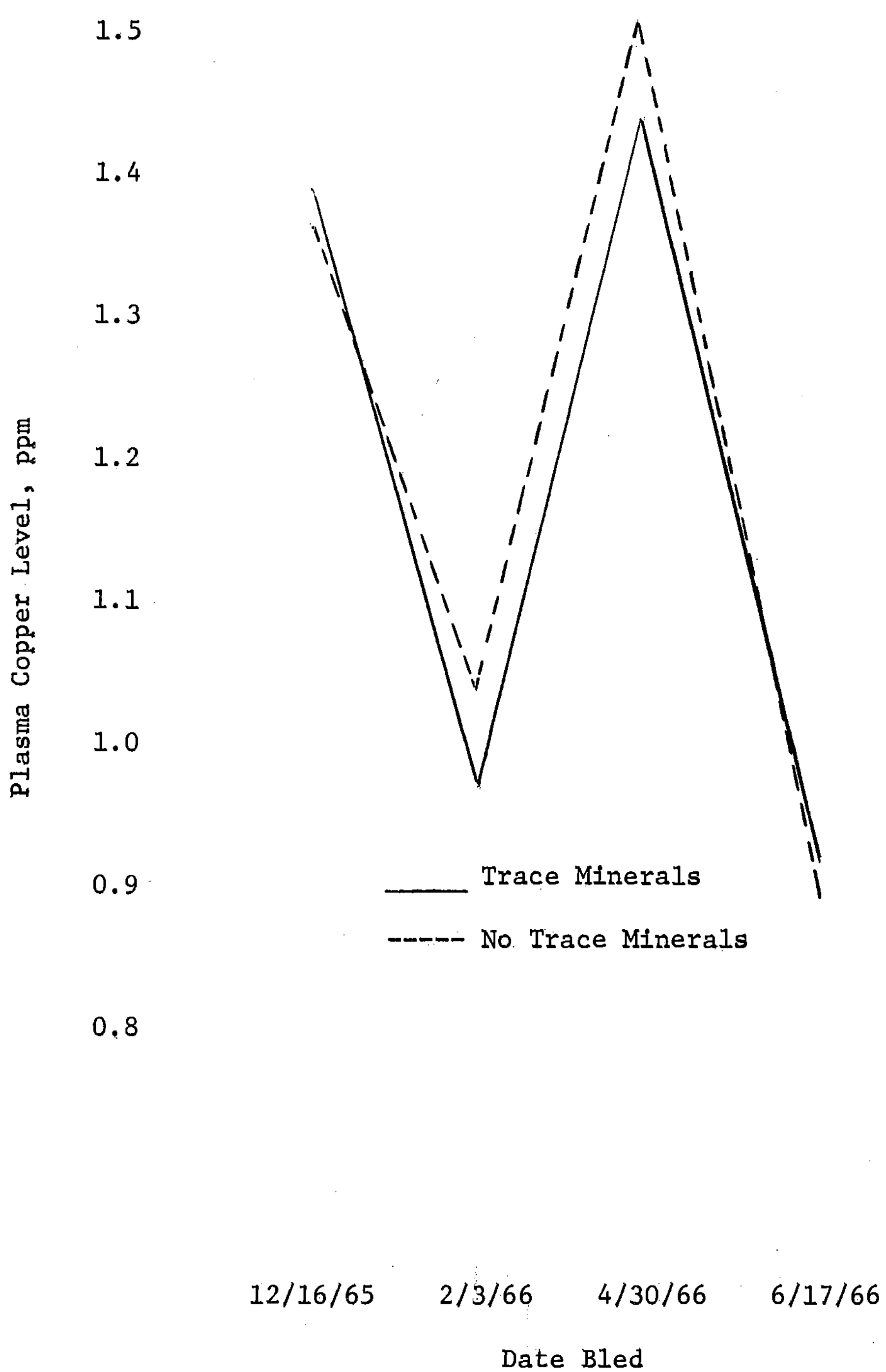

Figure 5. Influence of Trace Minerals on Plasma Copper Level

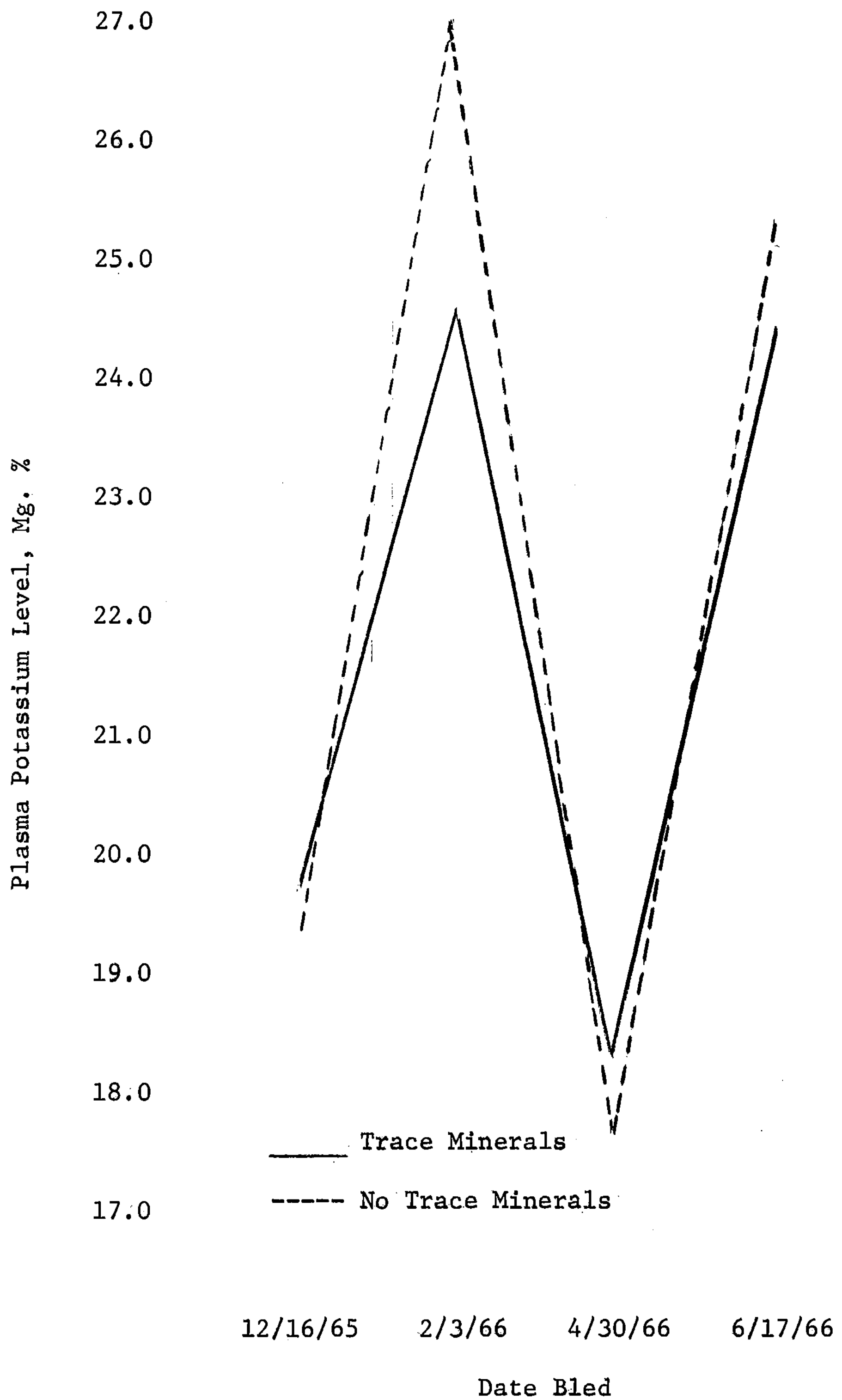

Figure 6. Influence of Trace Minerals on Plasma Potassium Level

significantly. Calcium levels obtained at the first bleeding (December 16, 1965) were about one-half the level considered to be normal. The level of the other minerals at this time was considered to be normal. Since a mineral mix containing calcium and phosphorus was before the animal at all times, it seems improbable the calcium level was actually this low. Rather, a laboratory mistake would more nearly explain the results. The plasma calcium levels at the other times were within the accepted range.

The cows receiving supplemental trace minerals had a significantly lower ($P<.01$ and $P<.05$, respectively) plasma magnesium level on April 30, 1966, and June 17, 1966. A similar trend was also evident at the first two bleedings but the differences were not significant.

The cattle receiving the trace minerals had a significantly lower ($P<.05$) plasma potassium level at the second bleeding (February 3, 1966). No logical explanation can be offered, but it should be pointed out that both levels were within the accepted range.

There were no observable symptoms of a trace mineral deficiency or excess for the three years of the experiment.

SUMMARY

A three year experiment was conducted to determine the effect of injecting range beef cows with vitamin A and/or E and supplementation with the trace minerals copper, iodine, zinc, iron, cobalt and manganese. A total of 212 cows were used in the experiment the first year, 193 the second year and 228 the third year.

Data obtained on the cows were conception rate, calf survival, and winter weight changes. A random sample of the cows was bled in December, February, April and June during the third winter. The blood samples were analyzed for calcium, copper, zinc, potassium and magnesium by atomic absorption spectrophotometry. Data obtained on each calf included birth date, birth weight, sex, weaning weight, condition at weaning and conformation score at weaning. The weaning weights of the calves were adjusted for sex of calf, age of dam and to a constant age of 205 days.

Composite samples of the feed and pasture grasses were taken the third winter of the experiment and analyzed for dry matter, ash, crude protein, fat, fiber, N.F.E., calcium, magnesium, potassium, copper, zinc, sodium, iron, phosphorus and manganese.

Conception rate, calf survival and weight changes of the cows were not significantly influenced by the injection of vitamin A and/or E or by supplementation with trace minerals.

Birth weight, 205-day adjusted weaning weight, average daily gain

and weaning grade and condition of the calves were not significantly influenced by treatment. There was a significant ($P<.05$) interaction between vitamin A and E on birth date of the calves.

The addition of trace minerals to the cow's diet did not significantly influence any of the measurements taken on the cows or calves. The cows receiving supplemental trace minerals had a significantly lower ($P<.01$ and $P<.05$, respectively) plasma magnesium level in April and June, and a significantly lower ($P<.05$) plasma potassium level in February.

There were several indications in the experiment that injection of vitamin E lowered the performance of the cattle. Birth date, 205-day adjusted weight, average daily gain, weaning grade, weaning condition and conception rate were lower for the vitamin E group.

The analysis of the feedstuffs and the estimated daily intake tables show that the carotene, alpha-tocopherol and trace mineral requirements of the cattle were met or exceeded without vitamin or trace mineral supplementation.

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