STUDIES WITH CALVES GRAZING WHEAT PASTURE

By

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Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1958

Submitted to the
faculty of the Graduate College of the
Oklahoma State University in partial
fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
May, 1968

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WHEAT PASTURE

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ACKNOWLEDGEMENT

The author wishes to express his appreciation to Dr. S. A. Ewing of the Animal Science Department for his guidance during the course of this study and in the preparation of this thesis.

Grateful acknowledgement is given to Mr. Derald McNutt and Mr. Raymond Edwards for their help in caring for the experimental cattle and in maintaining necessary records.

Appreciation is also extended to fellow graduate students at Oklahoma State University and to Drs. W. F. Taggart, Don Gill and Charles Nichols of the Oklahoma Extension Livestock Staff for their encouragement and assistance.

The author is indebted to Mr. Cliff Elder of the Agronomy Department and Dr. E. C. Nelson of the Biochemistry Department for their helpful suggestions and laboratory assistance.

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INTRODUCTION

The utilization of small grain winter pasture is one of the important systems of beef production in Oklahoma. Approximately five million acres of wheat and one million acres of other small grain are planted annually. Many producers specialize in winter pasture programs, using variable amounts and kinds of supplemental feed in an effort to obtain higher gains, maintain gains in severe weather and increase carrying capacity of a given acreage.

The kind and amount of supplemental feed, if any, that should be provided for animals on small grain pasture to improve performance, increase carrying capacity and assure maximum pasture utilization has not been well established. It is also reasonable to expect that limited amounts of small grain pasture, high in protein, could be utilized to effectively meet the protein shortages of other energy feeds.

Another pertinent area for consideration, in conjunction with small grain pasture work, is the influence of nitrogen fertilization on the nitrate content of the plant and any associated influence on the status of vitamin A nutrition in the grazing animal. There have been divergent results in attempting to determine the effects of nitrate on vitamin A nutrition. Some researchers suggest that other nutrients may be involved in this apparently complex problem. Due to increased amounts of nitrogen fertilizer being used in small grain production, the nitrate problem takes on added significance.

A third area of interest is the influence of stilbestrol as a possible growth stimulant for young cattle grazing small grain pasture. Several tests, using stilbestrol implants, have shown favorable growth response in cattle grazing improved pastures but little information is available for cattle grazing small grain pasture.

The primary objectives of this study include:(1) the influence of various nitrogen fertilization rates on nitrate content of wheat forage and any associated influence on carotene and vitamin A levels of the animal consuming the forage, (2) the influence of supplemental grain on performance of calves grazing wheat pasture and (3) an evaluation of stilbestrol implants as a possible gain stimulant for cattle grazing this type of pasture.

REVIEW OF LITERATURE

This review is presented in three phases with major areas covering influence of nitrate on the vitamin A nutrition of animals, supplemental feeding of cattle grazing small grain pasture and the influence of stilbestrol treatment on the grazing animal.

Influence of Nitrates on Vitamin A Nutrition of Animals. Some of the earlier work with dietary nitrate and its relationship to vitamin A nutrition in animals was reported by O'dell et al. (1960). A ration containing 0.3 percent potassium nitrate depressed growth in rats and reduced liver vitamin A levels. Apparently the nitrate also precipitated a vitamin E deficiency in rats consuming a diet which would normally be considered adequate in this vitamin.

Hale et al. (1961) evaluated the effects of different levels of concentrate and nitrate on vitamin A stores and feedlot performance of steers. This study involved a 2 X 2 factorial design with rations containing either 71.3 or 54.3 percent TDN and with or without one percent additional potassium nitrate. The high concentrate ration caused a significantly greater reduction of liver vitamin A than the low concentrate ration. Nitrate level had no significant effect on average daily gain or on vitamin A liver stores. Weichenthal et al. (1963) observed a significant depression in rate of gain in steers when sodium nitrate was added at the rate of one percent of the total ration. Supplementation with vitamin A did not improve gains of steers receiving this level of sodium nitrate. The nitrate treated steers consumed two pounds less feed daily than the control groups. The lower feed intake observed was assumed to be a major factor in reducing rate of gain. Steers supplemented with vitamin A did have significantly higher levels of liver vitamin A than the non-supplemented steers.

Smith et al. (1962) fed steers either a hay or silage ration with or without potassium nitrate added at the rate of one or two percent of the diet on a dry matter basis. Gains were slightly, but not significantly, decreased by the addition of nitrate. Nitrate exerted no significant effect on liver vitamin A stores. Sheep fed concurrently for 30 days from the same source of hay or silage, with or without potassium nitrate added as four percent of the dietary dry matter, exhibited no significant differences in weight gain or vitamin A concentration in the liver tissue.

Wallace et al. (1964) fed a low carotene depletion ration for 100 days to 36 Hereford heifer calves and yearlings. The cattle were then fed individually for a 100 day experimental period. The ration variables during the experimental period were 20 or 40 percent concentrate and 0.0, 0.6 or 1.2 percent calcium nitrate. Feed consumption and daily gains were not significantly influenced by nitrate level in the ration regardless of animal class or concentrate level. No apparent effect on carotene or vitamin A levels of liver or plasma was observed.

In a study with feeder lambs, Hatfield and Smith (1963) included potassium nitrate in a ration containing either soybean meal or urea as a crude protein source. Potassium nitrate made up 1.5 percent of the diet the first 55 days, 4.0 percent the next 25 days and 5.0 percent the last 23 days of the trial. The lambs fed soybean meal gained significantly more weight than lambs fed urea. Nitrate reduced gains in lambs fed soybean meal but increased gains in lambs fed urea. Nitrate appeared to reduce liver vitamin A stores in lambs receiving soybean meal.

Cline *et al.* (1963) in a 2 X 2 factorial design, administered weekly injections of vitamin A at the rate of 98,000 I. U. per lamb. Potassium nitrate constituted 4.0 percent of the air dry feed. The treatments did not have a significant influence on weight gain. Injections of vitamin A did, however, significantly increase liver stores of vitamin A.

Goodrich *et al.* (1964) reported that a ration containing 2.5 percent sodium nitrate did not significantly affect rate of gain, feed efficiency, or carcass grade of lambs. Plasma vitamin A levels were similar between treatment groups and no nitrate toxicity symptoms were observed in the lambs. The addition of 3000 I. U. of vitamin A to the ration did not alter vitamin A stores. In a second trial with lambs, a dietary level of three percent sodium nitrate resulted in seven deaths in the first three weeks. The addition of 4100 I. U. of vitamin A daily to the ration did not appear to provide protection against toxicity. Apparently this level of nitrate did not influence plasma vitamin A levels but a depletion in liver vitamin A did occur. Vitamin A supplementation did, however, show some influence on the extent of depletion. These two experiments indicate that levels of nitrate approaching acutely toxic rates may reduce tissue vitamin A stores but may be of secondary importance to the immediate hazard of nitrate toxicity.

Soil fertility and its relationship to nitrate content in feeds was studied by Jordan _et al_. (1961). Corn silage from four fields, that varied in natural nitrogen fertility and seeded to provide variable plant population density, was fed to steers to study any effects on vitamin A status. The levels of potassium nitrate on a dry matter basis in the silage produced from the four fields were: 0.16, 0.18, 0.75 and 0.63 percent. Average daily gains were: 1.13, 1.33, 1.24 and 1.40 pounds, respectively. After 133 days on the silage ration, liver vitamin A levels were equal for all lots. During the subsequent finishing period, some of the steers received 8,000 I. U. of dietary vitamin A supplement. There was no appreciable difference in rate of gain during the finishing period that could be attributed to the treatments employed.

Zimmerman _et al_. (1962) fertilized three corn silage plots with zero, 220 lbs. of nitrogen or 220 lbs. of nitrogen plus 212 lbs. of phosphate per acre. The levels of nitrate observed in the dry matter were 0.19, 0.32 and 0.23 percent, respectively. Silage, harvested from the three plots, yielded comparable quantities of dry matter and contained similar levels of crude protein and phosphorous. Respective average daily gains for steers fed silage from the plots were 1.76, 2.12 and 2.42 pounds. Vitamin A liver stores were similar in the three groups.

In studying the effects of nitrate on reproduction, growth and lactation, Davison et al. (1963) used 40 grade Holstein heifers divided equally into four groups. The heifers fed nitrates were sub-divided and fed either 20 or 30 grams of nitrate ion per hundred pounds of body weight daily. Heifers began receiving nitrate at one of the following stages of the trial: three estrous cycles prior to breeding, the 40th day of pregnancy or the 150th day of pregnancy. The nitrate was discontinued at parturition. One death and one abortion occurred in the heifers fed the 30 gram rate. Rate of growth, length of gestation, milk production and birth weight of calves were similar for all groups. The addition of nitrate did not alter levels of plasma or liver vitamin A.

Davison et al. (1964) fed nitrate levels of 0.0, 440 or 660 mg. per kg. body weight daily to dairy heifers beginning three estrous cycles before breeding, or at 40, 150 or 240 days of pregnancy. The supplemental nitrate was continued to 30 days after parturition at which time the heifers were slaughtered. One abortion occurred in the group fed the lowest level and two abortions and two deaths occurred in the highest level of nitrate. Growth rate, length of estrous cycle, length of gestation, plasma and liver vitamin A and carotene levels, birth weight and performance of calves were similar in all groups. Davison *et al.* (1965) reported similar results with pregnant ewes. Two deaths, five abortions and two stillbirths occurred in ewes receiving 2.6 or 3.4 percent nitrate levels. Liver and plasma vitamin A levels apparently were not affected by the addition of dietary nitrate.

Smith *et al.* (1964) found that steers depleted of vitamin A stores then fed 60,000 I. U. daily of vitamin A palmitate, during a 56 day fattening period, performed as well and exhibited no effect on vitamin A status when urea was added as one half of the nitrogen required. Lambs fed a purified diet containing urea as the major source of nitrogen for 97 days had lower liver stores of vitamin A (68 mcg. per gram liver) than expected. Low gains (0.04 lbs. per head daily) and the depressed vitamin A level may have been due to protein deficiency and not urea. Using the same lambs, a conventional ration containing five percent urea and twelve percent soybean meal protein did not alter the total liver content of vitamin A.

Tillman (1965) reviewed some of the basic concepts concerning the metabolism of nitrates and vitamin A and concluded that any factor which blocks the reticulo-endothelial system of animals reduces vitamin A levels. Such things as viral or fungal infections, high environmental temperatures and the stress of high production may tend to increase the vitamin A requirement. It was suggested that mineral adequacy, thyroid function and vitamin E be considered in studying the influence of nitrate on vitamin A.

A number of workers have suggested that toxic conditions and unpalatability may be the primary considerations concerning dietary nitrate rather than any influence on vitamin A utilization and storage. Hanway et al. (1963), in a review of the nitrate problem, reported that the toxicity of a given amount of nitrate varies greatly depending on such factors as type of ration and rate of intake. Hanway and co-workers also concluded that toxic amounts of nitrates are most likely to be found in plants receiving heavy applications of manure or nitrogen fertilizer, especially if normal growth and development of the plants are altered by drouth, disease, herbicides or other factors.

Hanway et al. (1963) reported that absorption of nitrate by hemoglobin results in oxyhemoglobin being changed to methoglobin, which does not release oxygen to the body cells. Experimental data indicates that 0.3 percent nitrate or 3,000 parts per million on a dry matter basis may be considered a maximum safe amount in forages. High energy feeds tend to increase animal tolerance to nitrates.

The variability of experimental results concerning the influence of nitrate on liver vitamin A stores indicates the need for further work in this area. In the experiments reviewed there appeared to be little, if any, effect of nitrate on rate of gain or on reproduction through the reduction of plasma or liver vitamin A levels. With the addition of dietary nitrate, reduced palatability and nitrate toxicity appear to be the primary factors affecting rate of gain and reproduction.

Supplemental Feeding of Cattle Grazing Small Grain Pasture. McCormick *et al.* (1958) conducted a four year experiment to study the effects of different kinds of supplemental feeds fed to steers fattened on small grain pasture. The effect of supplementing steers at different times during the grazing period was also studied. The following treatments were used in the study.

(1) (control) Pasture only.

(2) Five pounds of ground ear corn per day.

(3) Three pounds of corn cobs and two pounds of molasses per day.

(4) Costal Bermuda grass hay self-fed.

(5) Eight pounds of ground corn per day the last half of the grazing period.

(6) Pasture only followed by drylot the last 35 days.

There was little difference in dressing percent, slaughter grade and carcass grade for these treatments. The average gain for steers pastured on small grain and then fed 35 days in drylot was significantly greater than the other treatments. This group's slaughter grade was one third higher but it had the highest cost per pound of gain. Feed cost per unit of gain was similar for the steers that remained on small grain pasture throughout the test. The steers receiving only small grain pasture gained significantly less than supplemented steers. Yellow carcass fat was characteristic of all treatments.

A three year test with steers comparing drylot feeding with limited feeding of grain on small grain pasture and with small grain pasture alone was conducted by McCormick et al. (1958). The drylot steers were fed corn, cottonseed meal and peanut hay. The small grain pasture consisted of oats and crimson clover. The three year average daily gain and cost per 100 lbs. of gain for the drylot group was 2.66 lbs. and $21.56. For the group supplemented on pasture, the average daily gain was 2.71 lbs. at a cost of $22.41 per 100 lbs. of gain. The daily gain of cattle grazing pasture only was 2.29 lbs. with a cost of $16.23 per 100 lbs. of gain. The cattle fattened on pasture graded one carcass grade lower than the other two groups.

In a third trial with steers on small grain pasture, McCormick et al. (1962) used the following treatments.

(1) Finishing ration in drylot.

(2) Initally in drylot and then placed on oat pasture.

(3) Oat pasture only.

(4) Rye pasture only.

(5) Limited grazing time on small grain pasture.

Costs per hundred lbs. of gain were 24.64, 22.36, 19.35, 22.97 and 22.43 dollars, respectively. Drylot steers returned the least profit and steers on oats only were the most profitable.

Neal and Jones (1958) conducted a study with oat pasture using five groups of steers averaging 454 pounds. The treatments were:

(1) Self-fed milo on oat pasture.

(2) Oat pasture only (two groups of steers).

(3) Alfalfa-oat pasture.

(4) Limited milo on oat pasture.

The self-fed and limited supplemental groups and one nonsupplemented group on oat pasture were full fed in drylot following removal from pasture. The other two non-supplemented groups were placed on sudan-alfalfa pasture for 66 days and then were finished in drylot. The supplemented groups finished earlier and were marketed at lighter weights. They required more concentrates in the fattening process than the non-supplemented groups. Little difference was noted between oat-alfalfa steers and those on oat pasture only. The non-supplemented groups were the most profitable and in the supplemented steers, the self-fed group returned more profit than the group receiving limited supplement.

Baird and Sell (1956) conducted two trials in consecutive years using high grade Hereford calves to study supplemental feeding on temporary pasture. The temporary pasture consisted of a mixture of oats, rye-grass and crimson clover. The treatment comparisons were: (1) pasture only, (2) pasture supplemented with corn and (3) drylot. The two year average daily gains were: 2.64 lbs. for the calves on pasture only, 2.66 lbs. for the cattle receiving ground corn on pasture and 2.14 lbs. for drylot animals. The cost per hundred pounds of gain was: 13.87, 16.82, and 18.40 dollars, respectively. Supplemental feeding lowered net return on temporary winter pasture in the two trials.

Gill and Coats (1952) placed two groups of yearling steers on a small grain pasture test in which one group received pasture and the second group received supplemental corn after being on the small grain pasture for 56 days. Both groups grazed small grain pasture 175 days. A third group was fed a finishing ration in drylot. The steers in drylot showed the smallest net return per steer. From these results it appears that yearling steers may be finished for market more economically on small grain pasture than in drylot. The yearlings receiving supplemental feed while on pasture gained 0.4 pounds per head more daily than the cattle on pasture. However, the increased weight and carcass grade were not sufficient to offset the additional feed cost. Crockett and Arnold (1952) reported similar findings in studies over a four year period. Steers on good winter pasture returned considerably more profit than steers on a full ration of corn and cottonseed meal in drylot. Average daily gain for drylot steers was 2.19 and 1.87 pounds for steers grazing small grain pasture.

Marshall (1957) found little advantage in supplementing stocker heifer calves on oat pasture with two pounds of concentrate. However, heifers offered western prairie hay consumed 1.9 pounds per day and outgained the heifers on oat pasture only by 0.39 pounds per head daily. There was no apparent influence of dry roughage on fecal consistency. Swanson (1935) and Swanson and Anderson (1951) reported that cattle grazing wheat pasture with dry roughage available will derive 70 to 85 percent of their ration from the wheat pasture.

In reviewing previous tests, Southwell and Parham (1955) concluded that small grain pasture is a very economical feed for fattening cattle. Steers on small grain pasture in the Southern states will gain as rapidly as steers in drylot on high energy rations. The yellow color of fat is objectionable in the meat trade and results in lower market prices of one to two cents per pound for cattle fattened on small grain pasture. Steers receiving supplemental grain grade slightly higher but have a higher cost per pound of gain than steers on pasture only. It was concluded that if any supplemental feed is provided to cattle while grazing small grain pasture it should be high in energy. Baird and Sell (1954) agreed with this opinion that only high energy feed supplements should be used in conjunction with small grain pasture.

McMillen and Langham (1942) supplemented steers on wheat pasture with sumac fodder and a mineral mixture. A second group received a mineral mixture in addition to wheat pasture and the control group received only wheat pasture. Weight gains were: 1.54, 1.39 and 1.47 pounds per day, respectively. The steers receiving sumac fodder consumed 0.9 pounds of fodder per head daily.

Grain supplementation and its effect, if any, on cattle grazing small grain pasture was explored by McCampbell and Well (1959). Animals were allotted on the basis of weight, sex, sire and feeder grade. Treatments and average daily gains were: (1) drylot, 1.96; (2) pasture only, 1.46; and (3) pasture and grain, 1.65 pounds per day. Drylot gains and carcass grades were significantly higher than pasture lots. Small grain pasture was severely damaged by a mid-winter freeze and may have been the limiting factor in this test rather than the treatments imposed.

In general, results from the feeding of roughage or concentrate supplements to cattle grazing small grain pasture has been economically unfeasible. However, when there is insufficient small grain forage available, supplemental feeding may be necessary and the more recent research indicates that high energy supplements should be used largely because the cost per unit of net energy may be lower in concentrates than in roughages.

<u>Influence of Stilbestrol Implants on the Grazing Animal</u>. Clegg *et al*. (1955) conducted twelve different trials consisting of 318 treated (stilbestrol implanted) lambs of both sexes and an equal number of controls in different regions of California. These trials were varied to include animals ranging from an initial weight at the start of

treatment of approximately 20 lbs. up to approximately 60 lbs. In all except one trial, the animals received one 12 mg. or one 15 mg. stilbestrol pellet implanted in the ear. In the exception, an additional group of wether lambs received three pellets (36 mg.) of stilbestrol. The results indicate a significant increase in rate of gain due to treatment regardless of age, sex or dietary regime. Animals of younger ages responded as effectively to treatment as older animals. There was no difference in the relative increase in rate of gain of treated animals of either sex, nor did differences in diet affect the response. There was no difference in the relative increase in rate of gain of wether lambs treated with 12 or 36 mg. levels of stilbestrol.

Perry <u>et</u> <u>al</u>. (1951) conducted a similar study with sheep. This experiment was designed to investigate the effect of subcutaneous implantation of stilbestrol in suckling lambs on pasture. Ninety-seven native wether and 100 female suckling lambs averaging 46 lbs. in liveweight were divided into three groups. No grain was fed to the ewes or lambs. The trial started May 2, 1950 and terminated August 22, 1950. The subcutaneous implantation of either 12 or 24 mg. of stilbestrol significantly increased the gains of both ewe and wether lambs. There was no significant difference in response between the two levels of stilbestrol used. Treated lambs of both sexes exhibited marked mammary development during the first 28 days of the 112 day trial.

Five feeding experiments with yearling steers or heifers were conducted using high grain finishing rations, high roughage growing rations, or rations intermediate in grain and roughage content in studying the influence of oral administration of stilbestrol upon liveweight gains and feed requirements per unit of liveweight gain. Burroughs _et al._ (1955) reported that in each experiment and on each type of ration, liveweight gains were increased (averaging 20 percent) and feed requirements per unit of gain were reduced (averaging 11 percent) by incorporating stilbestrol in the feed in dosages of 5 or 10 mg. per head per day. The presence of stilbestrol in the feed increased feed consumption of the cattle an average of about five percent. No observable undesirable side effects from stilbestrol feeding occurred.

O'Mary _et al._ (1956a) evaluated stilbestrol implants in two experiments conducted with grazing steers. The first experiment involved 15 yearling and two-year old Hereford steers in thin condition. One half of the animals received 24 mg. stilbestrol implants per steer. The pasture consisted of mixed grasses and legumes (mostly oats and alfalfa). Average daily gain was 2.33 lbs. for the control and 3.02 lbs. for the stilbestrol treated cattle. In the second trial 21 yearling Angus and Hereford steers, in considerably better flesh than the animals in the previous trial, grazed mixed grasses and legumes. One half of the animals received 24 mg. stilbestrol implants. Average daily gain for the controls was 1.25 lbs. and the stilbestrol treated steers gained 1.83 lbs. Treatment effects in both trials were significant. O'Mary *et al.* (1956b) studied the influence of stilbestrol implantation in 475 pound steer calves grazing improved pasture. The steers were allotted on the basis of previous gain into groups designated as high and low gainers. One half of each group was implanted with 24 mg. of stilbestrol per animal. The experimental period encompassed 114 days. The average daily gain for the low gainers without stilbestrol was 1.02 lbs. as compared to 1.38 lbs. for the low gainers that were implanted with stilbestrol. The high gainers without stilbestrol averaged 1.37 lbs. daily as compared to 1.54 lbs. for the high gainers that received stilbestrol. The differences observed were significant.

O'Mary *et al.* (1959) found that steers which were implanted with stilbestrol while on pasture did not do as well when placed in drylot as steers that were not previously implanted. A second implant as the steers were placed in drylot resulted in some stimulation of daily gains. However, those steers implanted for the first time as they were placed in drylot responded most favorably to treatment. Average daily gain was 2.54 lbs. for the steers implanted in drylot only as compared to 2.23 lbs. for the steers implanted on pasture and in the feedlot.

In a study with stilbestrol treated cattle on temporary winter pasture, McCampbell and Sell (1959) observed no significant treatment differences. The small grain pasture was severely damaged by a mid-winter freeze which reduced all pasture gains. The severely damaged pasture may have limited treatment response.

A series of four experiments were conducted by Woods (1962) to determine the effect of stilbestrol implantation of steers on pasture when followed by feeding of stilbestrol in drylot. A total of 275 steers were used in this study, one-half of which were implanted with 12 or 24 mg. of stilbestrol at the start of the pasture season. At two sub-stations a 12 mg. implant was used and at two other sub-stations a 24 mg. implant was used. Implanting with 12 or 24 mg. implants increased rate of gain on pasture 17.8 and 14.9 percent, respectively. In the fattening phase the oral feeding of 10 mg. of stilbestrol daily per steer increased gains by 14.4 and 13.6 percent, respectively, for the non-implanted and 12 mg. implanted steers at two sub-stations. The oral feeding of stilbestrol increased gains by 11.2 percent for the non-implanted steers as compared to 7.9 percent for the 24 mg. implanted steers at the other two sub-stations. The steers previously implanted gained slightly slower than the non-implanted steers. Feed required per unit of gain was decreased by the feeding of stilbestrol. There was little difference in carcass grade scores in any of the treatments.

Seventy Hereford heifer calves weighing approximately 500 lbs. were used in two stilbestrol experiments by Dinusson <u>et al</u>. (1950). The treated heifers received 4 mg. of stilbestrol implanted subcutaneously in the shoulder region. Growth rate, feed efficiency and feed consumption were significantly increased by stilbestrol implantation in this study.

The above data indicates that stilbestrol implantation of grazing cattle can be expected to result in a gain response if available pasture is adequate to support the potential response.

EXPERIMENT I: INFLUENCE OF NITROGEN FERTILIZATION ON VITAMIN A STATUS OF CALVES GRAZING WHEAT PASTURE

Two trials were conducted in successive years to study the influence of different rates of nitrogen fertilization on the vitamin A status of calves grazing winter wheat pasture. Weaner heifer calves from the Oklahoma State University herd at the Fort Reno Experiment Station were used. The calves were allotted to treatments on the basis of age, source, weight and breed.

Trial I (Fall And Winter 1965-66)

Experimental Procedure. Twenty weaner heifer calves were selected to serve as experimental animals in this first trial conducted in the fall and winter of 1965-66. Five of the twenty heifers were selected at random from the group immediately prior to the grazing period for liver biopsy in order to estimate initial levels of liver vitamin A and carotene. The remaining 15 calves were allotted to three groups on the basis of weight in a randomized block design. Each group was then assigned at random to one of three fields which had been fertilized with 16 lbs. of nitrogen per acre as a starter application. One field (control) received no additional nitrogen and the other two received nitrogen applications of either 34 or 84 pounds after the wheat was up and prior to the beginning of the grazing season in November. The three levels of total nitrogen applied were 16, 50 and 100 pounds per acre. The stocking rate was approximately 1.1 acres per head. Prairie hay and cottonseed meal were fed during brief periods when the heifers were removed from the pasture due to rainfall. The grazing period consisted of 121 days from November 17, 1965 to March 18, 1966. The forage was sampled for nitrate analysis at the beginning and end of the grazing season and at one point (January) within the grazing period. Ten samples were randomly collected from each field during a collection period.

Blood samples were collected from all animals for plasma vitamin A and carotene analysis at the beginning and end of the grazing period and at an interim point (January) within the grazing period. Liver samples were collected by biopsy technique from all calves at the end of the test to determine liver vitamin A and carotene levels.

Results and Discussion. The results of Trial I are summarized in Table I. It is apparent from the data that the vitamin A status of calves, reflected by either plasma or liver levels of carotene and vitamin A, increased at approximately the same rate for all treatment groups. Differences in plasma or liver vitamin A levels for the three treatment groups were not significant ($P>.05$). Figures 1, 2, 3 and 4 further illustrate the similarity of liver and plasma vitamin A and carotene levels among the experimental groups. Zimmerman *et al.* (1962) reported no significant differences in liver vitamin A stores of steers receiving

TABLE I

INFLUENCE OF NITROGEN FERTILIZATION OF WHEAT PASTURE ON THE VITAMIN A STATUS OF BEEF CALVES, TRIAL I

Lot No.	I	II	III
No. of Animals	5	5	5
Acres/field	6	6	6
Weights			
Initial wt. (11/17/65)	434	434	434
Final wt. (3/14/66)	588	557	562
Net Gain	154	123	128
Plasma Carotene			
Mcg./100 ml. (11/17/65)	354	488	343
Mcg./100 ml. (3/18/66)	1648	1880	1612
Difference	+1294	+1392	+1269
Plasma Vitamin A			
Mcg./100 ml. (11/17/65)	25.88	30.20	29.16
Mcg./100 ml. (3/18/66)	56.10	61.60	53.30
Difference	+30.22	+31.40	+24.14
Liver Carotene			
Mcg./gram (11/3/65)	*5.2	*5.2	*5.2
Mcg./gram (3/18/66)	14.7	19.4	16.2
Difference	-9.5	+14.2	+11.2
Liver Vitamin A			
Mcg./gram (11/3/65)	*68.6	*68.6	*68.6
Mcg./gram (3/18/66)	153.3	161.1	156.7
Difference	+84.7	+92.5	+88.1
Forage Nitrate			
PPM-D.M. (11/17/65)	35	140	245
PPM-D.M. (1/1/66)	210	245	1485
PPM-D.M. (3/22/66)	280	280	560

*Five of the twenty heifers were selected at random for liver biopsy to obtain the initial levels of liver vitamin A and carotene prior to the grazing season.

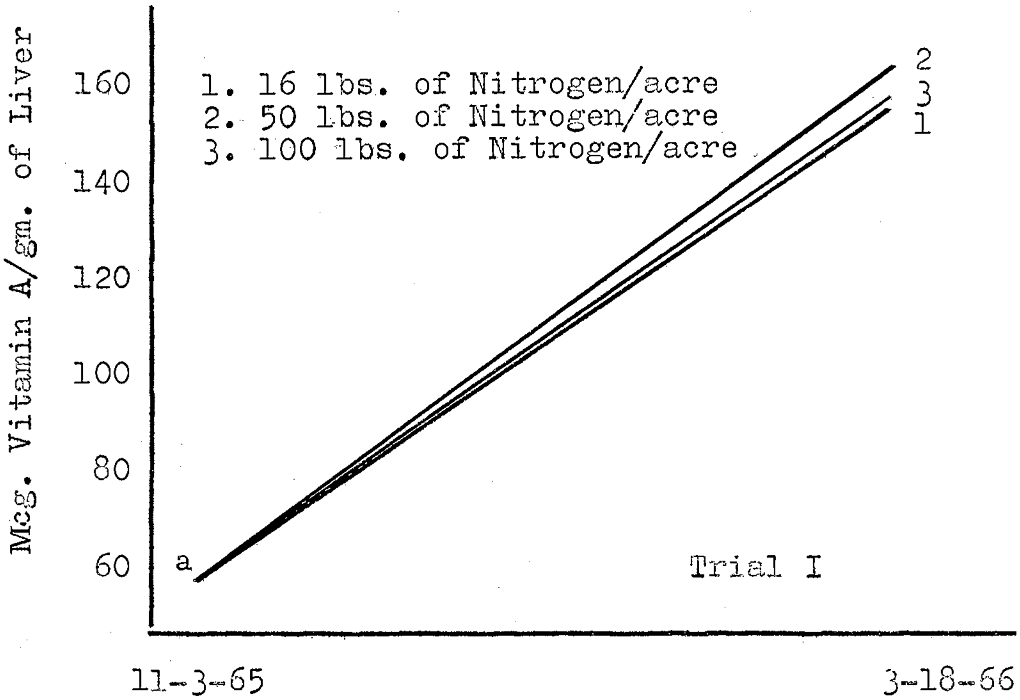

Figure 1. Influence of Level of Nitrogen Fertilization on Liver Vitamin A Concentration

[a]Five of the twenty heifers were selected at random for liver biopsy to obtain initial levels of liver vitamin A and carotene prior to the grazing season.

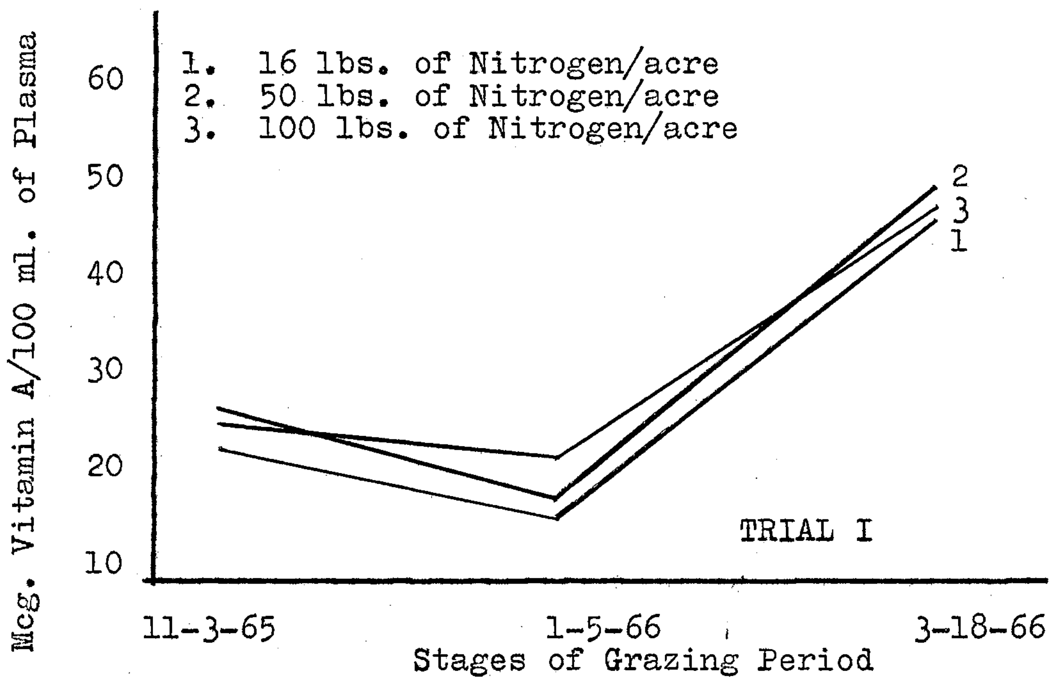

Figure 2. Influence of Level of Nitrogen Fertilization on Plasma Vitamin A Concentration

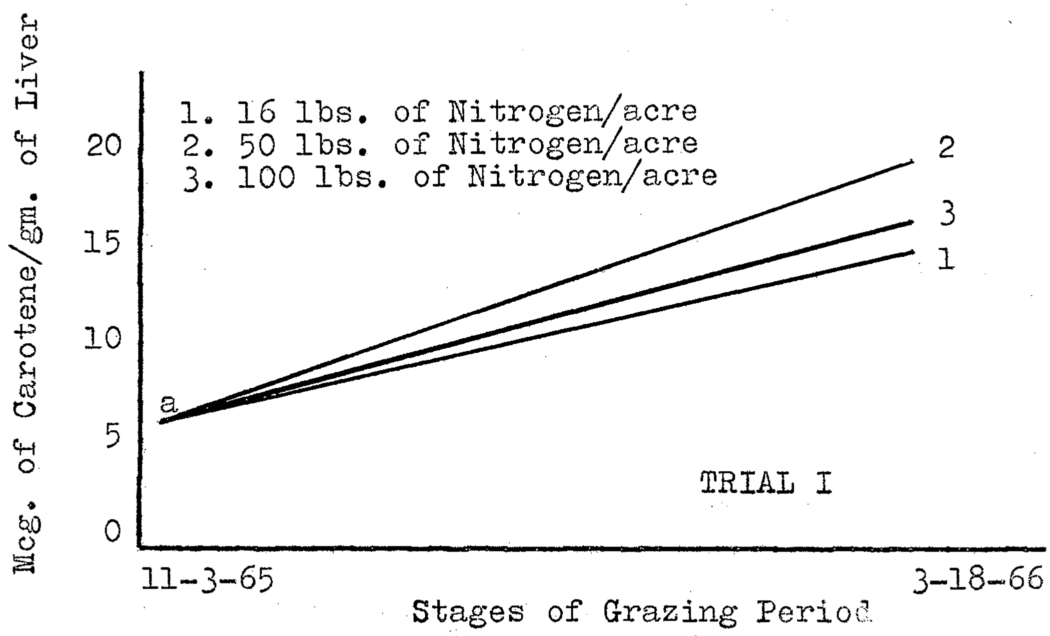

Figure 3. Influence of Level of Nitrogen Fertilization on Liver Carotene Concentration

[a]Five of the twenty heifers were selected at random for liver biopsy to obtain initial levels of liver vitamin A and carotene prior to the grazing season.

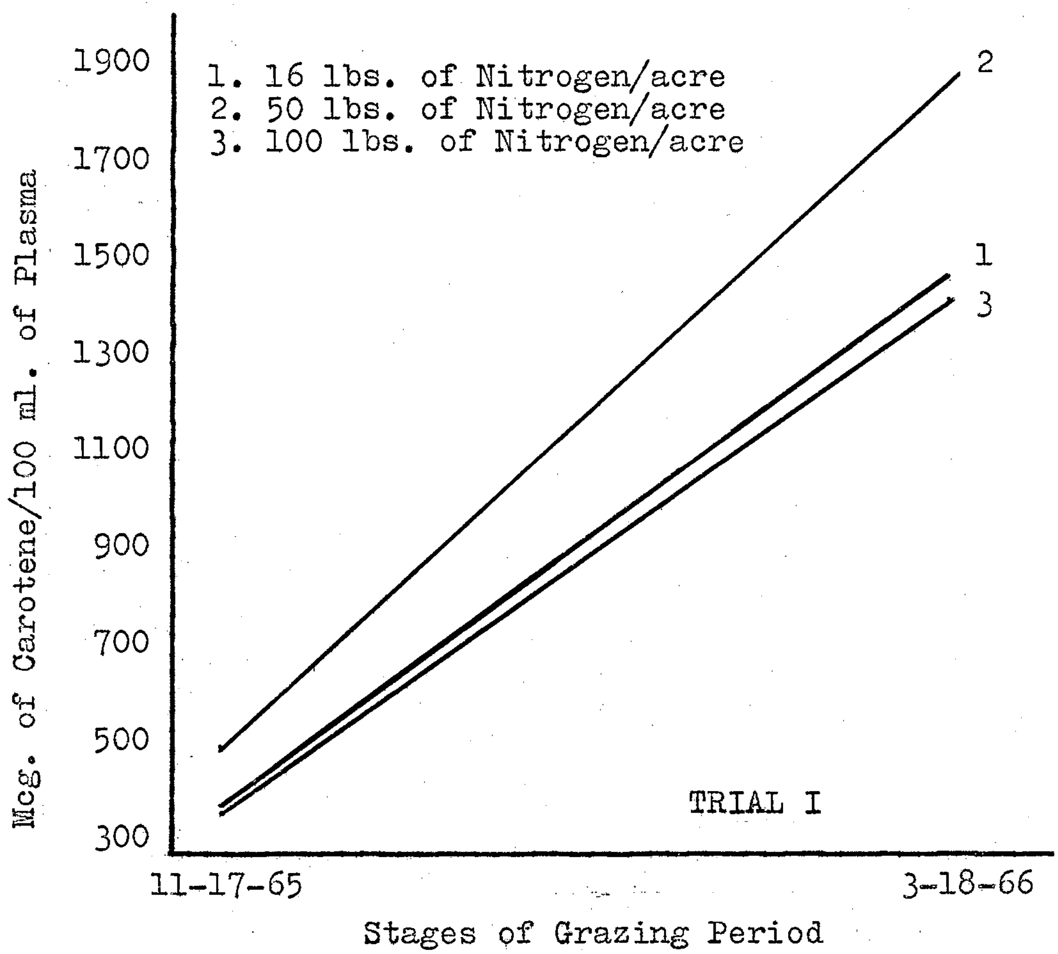

Figure 4. Influence of Level of Nitrogen Fertilization on Plasma Carotene Concentration

corn silage from plots that had received varying amounts of nitrogen fertilizer. Jordan et al. (1961) also observed little, if any, effect on vitamin A status of steers fed corn silage from fields that varied in natural nitrogen fertility.

The nitrate content of the wheat forage was closely related to the level of nitrogen applied (Table I). These data are in agreement with results reported by Zimmerman et al. (1962) who observed that nitrogen application rate and nitrate content of the plant were closely correlated. The highest concentration of nitrate was observed in the forage sample collected in January from Treatment III (100 lbs. of nitrogen per acre). This level (1485 ppm), however, was below the level that is normally considered toxic (Hanway et al. 1963) and apparently had no important influence on the status of vitamin A nutrition of the calves consuming the pasture.

Trial II (Fall And Winter 1966-67)

Experimental Procedure. This trial involved 15 weaner heifer calves which were randomly allotted to three groups on the basis of weight in a randomized block design. The groups were randomly assigned to one of three wheat fields that had received various rates of nitrogen fertilizer. The fertilizer treatments applied on the wheat field were: Field 1, (control) 16 lbs. of nitrogen per acre applied at seeding time; Field 2, 100 lbs. of nitrogen per acre (16 lbs. starter and 84 lbs. applied in November); Field 3, 100 lbs. of nitrogen per acre (16 lbs. starter and 84 lbs. applied in November). Field three was to receive an additional 100 pounds of nitrogen in February but due to extremely dry weather this application was canceled.

The stocking rate was approximately 1.1 acres per head. No other source of feed was provided for the heifers except supplemental minerals. The grazing period consisted of 56 days extending from December 8, 1966 to Feb. 2, 1967.

Blood samples were collected for plasma vitamin A and carotene analysis at the beginning and at the termination of the grazing period. Forage samples were collected at the beginning and at the end of the grazing period for nitrate analysis.

Laboratory Procedure (Trial I & II)

Plasma vitamin A and carotene levels were determined by the Kimble procedure (Kimble, 1939). Liver vitamin A and carotene concentrations were measured by a modification of the method of Gallup and Hoefer (Bunnell, et al. 1954). Wheat forage nitrate content was determined by the procedure suggested by Johnson and Ulrich (Johnson and Ulrich 1950). The one-way classification of analysis of variance (Steel and Torrie 1960) was used to test for significant differences in carotene and vitamin A levels.

Results and Discussion. The results of this trial are summarized in Table II. As in Trial I it is apparent that the increase in plasma carotene content is similar for the three groups, although differences in carotene levels were

TABLE II

INFLUENCE OF NITROGEN FERTILIZATION OF WHEAT PASTURE ON THE VITAMIN A STATUS OF BEEF CALVES, TRIAL II

Lot No.	I	II[a]	III[a]
No. of Animals	5	5	5
Acres/field	6	6	6
Weights			
Initial wt. (12/8/66)	386	387	384
Final wt. (2/3/67)	465	446	447
Net gain	79	59	63
Plasma Carotene			
Mcg./100 ml. (12/20/66)	488.2	371.0	330.0
Mcg./100 ml. (2/3/67)	1109.0	835.4	640.0
Difference	+620.8	+464.4	+310.2
Plasma Vitamin A			
Mcg./100 ml. (12/20/66)	49.8	46.0	47.4
Mcg./100 ml. (2/3/67)	40.2	40.4	42.4
Difference	-9.6	-5.6	-5.0
Forage Nitrate			
PPM-D. M. (12/8/66)	362	933	957
PPM-D. M. (2/3/67)	175	280	315

[a]Lots II and III did not have access to adequate forage for approximately the last 30 days of the trial.

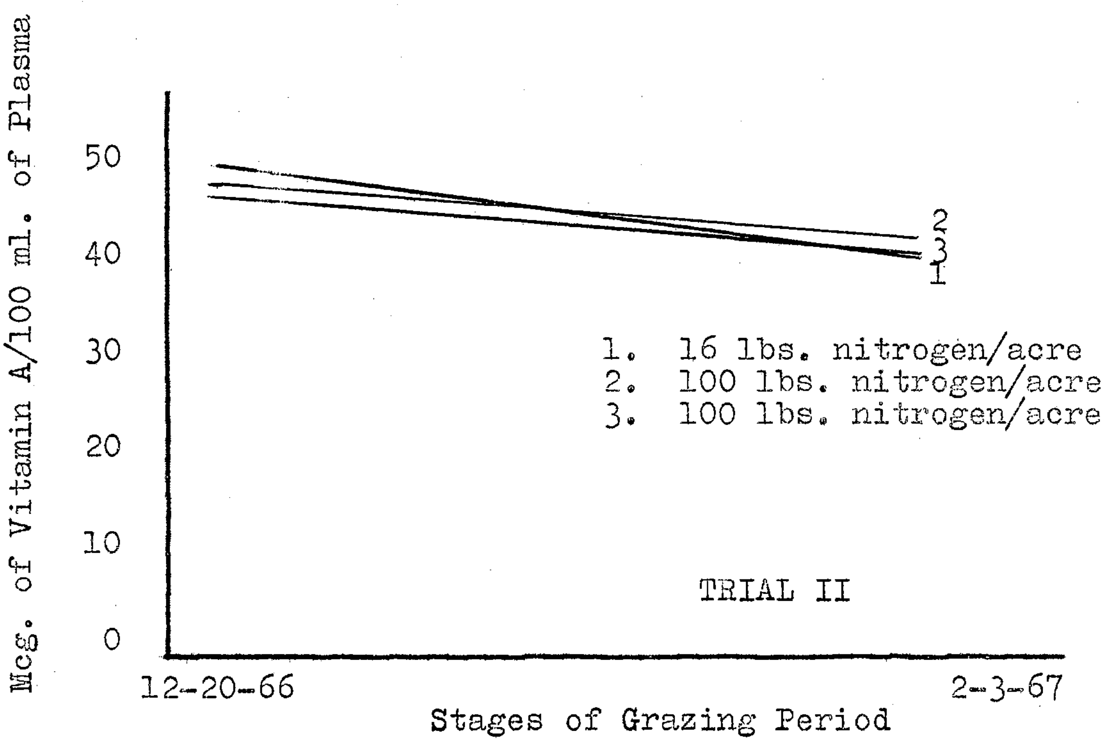

Figure 5. Influence of Level of Nitrogen Fertilization on Plasma Vitamin A Concentration

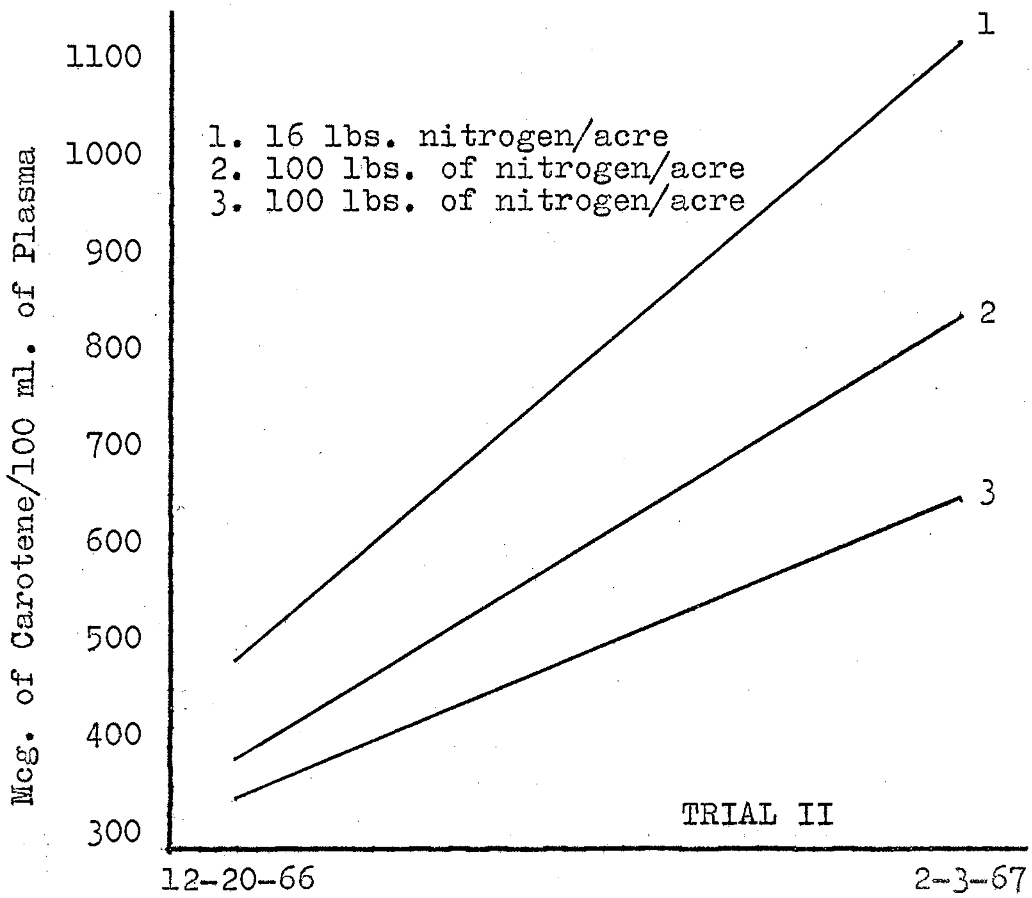

Figure 6. Influence of Level of Nitrogen Fertilization on Plasma Carotene Concentration

not significant (P>.05), the highest levels of carotene occurred in the cattle grazing the small grain pasture fertilized with 16 pounds of nitrogen per acre. Heifers on this treatment had access to adequate forage throughout the trial but heifers grazing the pastures receiving 100 pounds of nitrogen per acre appeared to be limited on forage the last 30 days of the test. This may account for the higher plasma carotene content (Figure 6) in the cattle on the low nitrogen level pasture.

There was a slight decrease in plasma vitamin A (Figure 5) levels for all treatments. The heifers grazing the wheat field receiving the least nitrogen (16 lbs./acre) declined slightly more in plasma vitamin A levels than the other treatments. Differences in plasma vitamin A levels were not significant (P>.05).

Initial forage nitrate levels were similar for the two fields receiving 100 pounds of nitrogen per acre but a lower level was observed for the field fertilized with 16 pounds of nitrogen per acre. Nitrogen was applied on December 7, 1966 and initial forage samples were collected on December 8, 1966. Therefore, levels of nitrogen application would not account for the initial differences in nitrate content. The reason for this variation is not clear. Forage nitrate levels at the end of the trial showed a marked decline for all of the treatments with the low level nitrogen field still exhibiting the lowest level. The first rainfall of any consequence, after application of the nitrogen fertilizer, was received on January 24, 1967. Since moisture must be present to move the nitrogen into the plant root zone and also make it available to the plant (Tucker, 1967), the absorption of the nitrogen into the wheat plant during the early part of this trial appears doubtful.

EXPERIMENT II: SUPPLEMENTAL FEEDING OF CATTLE GRAZING SMALL GRAIN PASTURE

Experimental Procedure. This trial involved twenty head of weaner heifer calves averaging approximately 470 pounds in weight. The heifers were randomly allotted, on the basis of weight, into two groups. One group was self-fed supplemental feed in addition to wheat pasture. The supplemental feed mixture consisted of 77 percent ground milo, 8 percent molasses and 15 percent chopped alfalfa hay. The other group served as a control group and received only wheat pasture.

The wheat pasture fields were adjacent and groups were rotated between pastures at approximately 30 day intervals. The stocking rate was approximately 4.8 acres per head which is considerably below the normal expected carrying capacity for the Ft. Reno area. This was necessitated by low rainfall during the period.

The cattle were weighed at approximately thirty day intervals throughout the trial after a 12 hour shrink without feed and water. The grazing period consisted of 92 days from December 8, 1966 to March 10, 1967.

All animals had free-choice access to a mineral mixture of one half salt and one half steamed bone meal and a separate mixture of salt and trace minerals.

Wheat forage samples were collected December 8, 1966, February 3, 1967 and March 10, 1967 to estimate the pounds of dry matter per acre available to the grazing animal. The forage sampling procedure involved clipping 36 inch rows at ten sites within each pasture.

Results and Discussion. Results of this study are summarized in Tables III and IV. The calves self-fed a high energy feed in addition to wheat pasture gained 28 pounds ($P<.05$) more than cattle receiving only wheat pasture during the 92 day treatment. Gill and Coats (1952), McCormick *et al.* (1958), Crockett and Arnold (1952), McCampbell and Sell (1959) and Southwell and Parham (1955) reported increased weight gains for cattle receiving supplemental grain in addition to small grain pasture. Baird and Sell (1956), however, observed no increase in weight gain in cattle receiving a similar treatment. The majority of the recent work, including this study, indicates that an increase in rate of gain may be expected when cattle grazing small grain pasture are supplemented with grain or a high grain ration.

Using estimated net energy values from Morrison (1951), the amount of supplemental feed consumed by cattle in this trial would account for 56.5 percent of the total energy required to support the observed rate of gain. This value suggests that carrying capacity may be increased considerably by supplemental feeding of a high energy feed. Elder (1967) indicated an increase of approximately 20 percent in possible carrying capacity with high energy supplementation when cattle consumed five pounds of grain daily while on

TABLE III

PERFORMANCE OF STOCKER HEIFER CALVES RECEIVING HIGH ENERGY SUPPLEMENTAL FEED ON WHEAT PASTURE

Treatment	Wheat Pasture	Wheat Pasture + Supplemental Ration[a]
No. of heifers	10	10
Acres/treatment	48	48
Weight		
Initial wt. (12-8-66), lbs.	471	477
Final wt. (3-10-67), lbs.	667	701
Total gain (92 days), lbs.	196	224
Daily gain, lbs.	2.13	2.43
Advantage for supplemented calves	---	0.30
Daily supplemental feed,[b] lbs.	---	8.93
Mineral & salt	Free Choice	Free Choice

[a]Supplemental ration consisting of 77 percent ground milo, 8 percent molasses and 15 percent chopped alfalfa hay fed free choice.

[b]Supplemental ration described in footnote[a].

TABLE IV

FORAGE YIELD OF SMALL GRAIN PASTURE USED IN SUPPLEMENTAL FEEDING TRIAL[a]

Treatment	Wheat Pasture	Wheat Pasture + Supplemental Ration[b]
Dry Matter/acre (12-8-66), lbs.[c]	434	308
Dry Matter/acre (2-3-67), lbs.	410	460
Dry Matter/acre (2-3-67), lbs.[d]	1046	690
Dry Matter/acre (3-10-67), lbs.	422	480
Average Dry Matter/acre, lbs.	562.4	484.5

[a]Ten samples were randomly collected from each field (36 inches of one row clipped one inch above soil surface) during a collection period.

[b]Supplemental ration consisted of 77 percent ground milo, 8 percent molasses and 15 percent chopped alfalfa hay fed free choice.

[c]The cattle were rotated on 1-13-67.

[d]The cattle were moved to new small grain fields on 2-3-67.

small grain pasture. Forage dry matter yields (estimated by forage clippings obtained at approximately 30 day intervals) did not indicate the possibility of a substantial increase in carrying capacity by supplemental feeding. The supplemented cattle in this trial consumed a total of 822 pounds of the supplemental ration per animal. Unless carrying capacity could be substantially increased as a result of supplementation of cattle grazing small grain pasture, this practice would appear economically unfeasible. A number of workers (McCormick et al., 1958; Baird and Sell, 1956; Gill and Coats, 1952; Crockett and Arnold, 1952 and Southwell and Parham, 1955) observed a significant increase in cost per pound of gain when supplemental high energy feed was provided to cattle grazing small grain pasture. There is a need for studies designed to carefully evaluate the influence of supplemental feeding on carrying capacity of small grain pasture. This type of study was planned in conjunction with the trial reported herein. Due to poor weather conditions, such studies had to be deferred to a later time. It should not be assumed that carrying capacity may be increased in direct relationship to energy consumed in the form of supplemental feed due to influences related to animal density, rate of gain and composition of gain.

It appears that rate of gain may be increased by supplementing cattle grazing small grain pasture with a high energy ration. However, the cost of increased gains may be prohibitive when compared to the expected selling price of the cattle. Implications relative to carrying capacity, however, are an important consideration.

EXPERIMENT III: INFLUENCE OF STILBESTROL IMPLANTATION ON GAIN OF CALVES GRAZING WHEAT PASTURE OR RECEIVING SILAGE

Experimental Procedure. The test involved forty head of weaner heifer calves weighing approximately 470 pounds. Due to a shortage of wheat pasture, the original experimental plan was changed so that one half of the heifers were maintained on wheat pasture and one half on sorghum silage. One half of each of these groups were allotted to receive supplemental energy feed in the form of a mixed ration consisting of 77 percent ground milo, 8 percent molasses and 15 percent chopped alfalfa hay. This plan resulted in four major treatment groups as follows:

1. Sorghum silage
2. Sorghum silage + Supplemental energy feed
3. Wheat pasture
4. Wheat pasture + Supplemental energy feed

Within each major treatment group, one half of the calves were selected at random to receive a 12 milligram stilbestrol implant at the beginning of the test. Initial and final weights were determined after a 12 hour shrink without feed and water. A mineral supplement consisting of equal parts of salt and steamed bone meal was provided free-choice. Salt plus trace minerals was also provided free-choice.

The experimental period consisted of 92 days extending from December 8, 1966 to March 10, 1967.

Analysis of variance for factorial experiments (Steel and Torrie, 1960) was used to test significance of stilbestrol implantation of cattle receiving silage or grazing wheat pasture.

Results and Discussion. The average gain responses to stilbestrol implants for calves consuming silage or wheat pasture as the major source of roughage are summarized in Table V. Table VI summarized the response to stilbestrol within the four major treatment groups. Faster gains were associated with stilbestrol treatment in three of the four groups. Stilbestrol implanted calves exhibited a significant ($P<.05$) increase in rate of gain over the control calves.

The cattle receiving only wheat pasture exhibited an average daily gain advantage of 0.39 pounds over the controls. This growth response to stilbestrol among cattle grazing small grain pasture compares favorably with observations reported by Dinusson, et al. (1950), O'Mary et al. (1956a), O'Mary et al. (1956b) and Woods (1962). In a study with cattle on winter temporary pasture, however, McCampbell and Sell (1959) observed no significant differences in rate of gain for stilbestrol treated cattle. These workers reported that a mid-winter freeze severely damaged the small grain pasture which reduced all pasture gains. The damaged pasture may have limited the treatment response.

In contrast to the growth stimulation of cattle on

TABLE V

RESPONSE OF STOCKER HEIFER CALVES TO STILBESTROL IMPLANTS

	No Supplemental Energy Feed		Supplemental Energy Feed[a]	
	Control	Implant	Control	Implant
No. of heifers	10	10	10	10
Initial wt. (12-8-66), lbs.	481	463	473	477
Final wt. (3-10-67), lbs.	609	611	669	698
Total gain (92 days), lbs.	128	148	196	221
Gain adv. over controls, lbs.		20		25
Daily gain, lbs.	1.39	1.60	2.13	2.40
Daily gain adv. over controls, lbs.		.21		.27

[a]Calves had access to supplemental energy feed consisting of 77 percent ground milo, 8 percent molasses and 15 percent chopped alfalfa hay.

TABLE VI

RESPONSE OF STOCKER HEIFER CALVES TO STILBESTROL IMPLANTS

	Sorghum Silage + Protein Supplement[1]	Sorghum Silage + Supplemental Ration[2]	Wheat Pasture	Wheat Pasture + Supplemental Ration[3]
No. of heifers	10	10	10	10
Acres/treatment			48	48
Initial wt. (12-8-66), lbs.	472	474	471	477
Final wt. (3-10-67), lbs.	553	667	667	701
Total gain (92 days), lbs.	81	193	196	224
Daily gain, lbs.	.88	2.10	2.13	2.43
Daily gain:				
Controls	.83	1.78	1.94	2.47
Stilbestrol implant[4]	.91	2.41	2.33	2.40
Daily Supplemental Feeds[1-3]				
Mixed feed	---	9.22	---	8.93
Cottonseed meal	1.50	1.00	---	---
Mineral & salt	Free Choice	Free Choice	Free Choice	Free Choice

TABLE VI (continued)

RESPONSE OF STOCKER HEIFER CALVES TO STILBESTROL IMPLANTS

[1]1.5 pounds of cottonseed meal daily.

[2]Supplemental ration consisting of 77 percent ground milo, 8 percent molasses and 15 percent chopped alfalfa hay fed at a level consumed by cattle on wheat pasture when provided free choice plus 1.0 lbs. cottonseed meal daily as supplemental protein.

[3]Supplemental ration described in footnote 2 provided free choice. No additional protein supplement was fed.

[4]Implanted with 12 milligram Stimplant (Pfizer).

wheat pasture only, cattle self-fed supplemental concentrate in addition to wheat pasture did not appear to respond to stilbestrol implants. There was essentially no difference in rates of gain between the implanted and unimplanted heifers. These data does not support the results obtained by Burroughs *et al.* (1955) who observed a 20 percent increase in growth rate of cattle receiving 5 to 10 mg. of stilbestrol daily in a ration intermediate in grain and roughage content. The reason for failure to observe a response to stilbestrol in the group of heifers receiving supplemental feed in addition to wheat pasture is not clear, however, sample size within the four major treatment groups was small. The low rate of gain in one stilbestrol treated animal in this particular treatment group had a marked influence on the results. Other than the low rate of gain there was no apparent reason for excluding the data collected on this animal; therefore, these data was included in the results.

The average total gain response from stilbestrol implants during the 92 day test, among all major treatment groups, was 23 pounds or an increase in daily gain of 0.26 pounds. The average daily gain for all implanted cattle was 2.10 pounds as compared with 1.84 pounds for the unimplanted controls. The percentage gain response associated with stilbestrol treatment was 14.1 percent.

SUMMARY

Two trials were conducted on wheat pasture in the fall and winter of 1965-66 (Trial I) and 1966-67 (Trial II) to study the influence of nitrogen fertilization on vitamin A status of the grazing animal. Three pens of five heifers each were allotted to six acre wheat pasture fields that had received 16, 50 or 100 pounds of nitrogen per acre. Differences in plasma or liver vitamin A levels observed within the three treatment groups were not significant (P>.05). In the second trial, however, the cattle grazing the pasture fertilized with 16 pounds of nitrogen per acre tended to exhibit slightly higher levels of carotene. Heifers on this treatment had more forage available throughout the trial than the other treatments. This may have accounted for the higher plasma carotene content observed for this group. The nitrate content of the wheat forage generally reflected the level of nitrogen applied. All forage nitrate levels were below the level that is normally considered toxic and apparently had no important influence on the status of vitamin A nutrition of the calves consuming the pasture.

One trial was conducted to study the influence of supplemental feeding of a high energy ration to cattle grazing small grain pasture. Twenty weaner heifer calves were allotted into two groups with the group self-fed a supplemental

high energy feed gaining 28 pounds more ($P<.05$) than cattle receiving only wheat pasture. Although it appears that rate of gain may be increased by supplementing cattle grazing small grain pasture with a grain ration, the cost of the increased gain must be considered. The influence of supplemental feed on possible carrying capacity is an important consideration.

One trial was conducted to study the gain response of cattle implanted with stilbestrol and provided either wheat pasture or silage. Forty stocker heifers were equally divided into two groups. One group was placed on wheat pasture and the other group fed silage plus a protein supplement. Half of each of these groups were fed supplemental energy feed which resulted in four major treatment groups. Within each major treatment group one half of the calves were selected at random to receive a 12 mg. implant at the beginning of the test. Faster gains were associated with stilbestrol in three of the four groups. Stilbestrol implanted calves exhibited a significant ($P<.05$) increase in rate of gain over the control calves. The average total gain response from stilbestrol implants during the 92 day test, among all major treatment groups, was 23 pounds or an increase in daily gain of 0.26 pounds. The average daily gain for all implanted cattle was 2.10 pounds as compared with 1.84 pounds for the unimplanted controls. The percentage gain response associated with stilbestrol treatment was 14.1 percent.

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APPENDIX

TABLE VII

ANALYSIS OF VARIANCE FOR NITRATE INFLUENCE ON PLASMA CAROTENE LEVELS (TRIAL I)

Sources of variation	df	MS	F
Total	14		
Treatment	2	21,208.47	0.2179
Error	12	97,313.73	

Tab. $F^{.05}_{2,\ 12} = 3.89$

TABLE VIII

ANALYSIS OF VARIANCE FOR NITRATE INFLUENCE ON PLASMA VITAMIN A LEVELS (TRIAL I)

Sources of variation	df	MS	F
Total	14		
Treatment	2	77.798	0.501
Error	12	155.213	

TABLE IX

ANALYSIS OF VARIANCE FOR NITRATE INFLUENCE ON LIVER VITAMIN A LEVELS (TRIAL I)

Sources of variation	df	MS	F
Total	14		
Treatment	2	76.06	0.068
Error	12	1,114.115	

TABLE X

ANALYSIS OF VARIANCE FOR NITRATE INFLUENCE ON LIVER CAROTENE LEVELS (TRIAL I)

Sources of variation	df	MS	F
Total	14		
Treatment	2	27.774	2.401
Error	12	11.5663	

Tab $F^{.05}_{2,\ 12} = 3.89$

TABLE XI

ANALYSIS OF VARIANCE FOR NITRATE INFLUENCE ON PLASMA VITAMIN A LEVELS (TRIAL II)

Sources of variation	df	MS	F
Total	14		
Treatment	2	31.267	0.257
Error	12	121.533	

TABLE XII

ANALYSIS OF VARIANCE FOR NITRATE INFLUENCE ON PLASMA CAROTENE LEVELS (TRIAL II)

Sources of variation	df	MS	F
Total	14		
Treatment	2	120,903.25	3.39[a]
Error	12	35,666.90	

[a]($P<.1$)

TABLE XIII

ANALYSIS OF VARIANCE FOR SUPPLEMENTAL HIGH ENERGY FEEDING AND STILBESTROL IMPLANTATION OF STOCKER HEIFERS CONSUMING WHEAT PASTURE OR SILAGE

Sources of variation	df	MS	F
Total	39		
Treatment	7	18,761.07	19.24*
A	1	54,022.50	55.40*
B	1	49,000.00	50.26*
C	1	5,062.50	5.19*
AB	1	17,640.00	18.09*
AC	1	722.50	0.74
BC	1	40.00	0.04
ABC	1	4,840.00	4.96*
Error	32	975.00	

*(P<.05)

A = Roughage (wheat pasture or silage)

B = Supplemental High Energy Feed

C = Stilbestrol Implantation (12 mg.)

VITA

Wayland Gale Thompson

Candidate for the Degree of

Master of Science

Thesis: STUDIES WITH CALVES GRAZING WHEAT PASTURE

Major Field: Animal Science

Biographical:

Personal Data: Born in Willow, Oklahoma, February 10, 1935, the son of Robert F. and Ann Thompson. Married Mattie Gail Arteberry April 11, 1958; father of two children, Deborah Carol and Catherine Lynn.

Education: Received the Bachelor of Science degree from Oklahoma State University, with a major in Animal Husbandry in May, 1958.

Experiences: Raised on a cotton and livestock farm in Southwest Oklahoma; 2/Lt. U. S. Army at Ft. Benning, Ga. and Ft. Chaffee, Ark. April 1958 to October 1958; Field Representative, North Texas Dairy Producers Assn. Nov. 1958 to Feb. 1960; 1/Lt. Associate Armored Officer's Career Course, Ft. Knox, Ky. April 1961 to Sept. 1961; Cpt. and Staff Officer, 45th Inf. Div.; Asst. Co. Agent, Okla. Extension Service, Sept. 1962 to June 1966; Extension Livestock Staff Assistant, Oklahoma, June, 1966 to June, 1967; own and operate farm and livestock enterprise in Western Oklahoma.

Professional Organizations: National Assn. of Co. Agricultural Agents and of the State Assn. of Okla.; National Guard Assn. of the United States.

Date of Degree: May, 1968