June, 1942

To the Committee on Graduate Study:

I am submitting to you a thesis written by Maywood Snyder entitled "A Comparison of the Feeding Values of Red Clover Hays of Low and Average Phosphorus Content, with and without a liberal Phosphorus Supplement, as the Roughage in the Wintering Ration for Growing Calves". I recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

A. P. Duncan
Major Professor

We have read this thesis
and recommend its acceptance:

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A COMPARISON OF THE FEEDING VALUES OF RED CLOVER HAYS OF LOW AND AVERAGE PHOSPHORUS CONTENT, WITH AND WITHOUT A LIBERAL PHOSPHORUS SUPPLEMENT, AS THE ROUGHAGE IN THE RATION FOR GROWING CALVES

A THESIS

Submitted to
the Committee on Graduate Study
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

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by
Maywood Snyder
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INTRODUCTION

This thesis is a report of work done by The University of Tennessee Experiment Station during the year of 1941-42 with which the writer assisted.

The experiment was a continuation of work begun in 1939 to obtain information relating to the effects of feeding red clover hays of varying phosphorus contents to growing beef calves (3). Results from the first year's work indicated that when beef calves were fed rations in which hays of varied phosphorus content furnished the roughage "the animals receiving the high-phosphorus red clover hay made better use of their feed, maintained a higher blood phosphorus and a thriftier condition, as evidenced by making greater gains and more growth than animals receiving the low-phosphorus hay of the same species".

At the end of the first year's experiment it was thought advisable to continue the work. The objective for the second year's work was to "study the growth of calves fed rations differing only in the phosphorus content of the red clover hays" (14). Results obtained for the second year were not consistent with those for 1939. The low phosphorus hay gave consistently better results as measured by gain in weight. It was thought that this might be due to certain undesirable factors (e.g. foreign matter) in the

high-phosphorus hay. Also, the phosphorus content of the low-phosphorus hay used during the second year contained 0.16 percent phosphorus which was considerably above that for either the first or third year.

The work was continued this past year to (A) compare the feeding value of a red clover hay of a good average phosphorus content with one of low phosphorus content, as the roughage in wintering ration for growing calves, and (B) to compare the effects of adding a liberal phosphorus supplement to rations fed for objective A.

REVIEW OF LITERATURE

Since Bible (3) and McFarlin (14) reviewed the literature on phosphorus in its relation to animal nutrition, it was decided to review some experimental data indirectly related to phosphorus metabolism.

A great amount of work has been published, especially since 1920, dealing with the various factors affecting plant composition. Several writers have analyzed the literature concerning the factors affecting the composition of crops. Beeson (2) and Vandecaveye (26) have each assembled summaries and lists of these publications.

One of the ways in which plant composition may be affected or partially regulated is by the application of fertilizer to the soil. In 1937 the total consumption of commercial fertilizer in the United States amounted to 8,240,000 tons (23). This amount of fertilizer, undoubtedly, influenced materially the yield and composition of crops produced in the United States. Without doubt, the primary reason for using fertilizer is to obtain greater yields, its influence on the composition of crops being considered as a secondary factor or possibly of no importance.

Discussion of the factors affecting plant composition will be limited chiefly to the literature relating to the influence of phosphate fertilizers under various conditions and concentrations on the phosphorus absorption by the plants.

Certain other factors related to phosphorus absorption or of historical importance will be mentioned.

Season was considered, in data reported in 1884 by Lawes and Gilbert (12), as one of the great factors affecting the phosphorus and potassium content of the wheat grain. The addition of manure to the soil did not affect the potassium or phosphorus content of the wheat grain but "grain grown under the influence of ammonium salts alone showed not only a wide range in the proportion of both phosphorus and potassium according to season, but much lower mean amount than either with farmyard manure or without manure".

Hills, J. L., et al, (10) in 1898, reported that the application of single fertilizer elements and various combinations of these elements did not have any marked influence on the chemical composition of the whole corn plant or on the corn grain produced on either sandy loam or clay loam soils.

The application of lime and superphosphate and lime alone increased the phosphorus and calcium contents of alfalfa grown on light, sandy, acid soils of Michigan. Price (22) reported that an application of 2 tons of limestone per acre increased the calcium content of the first cutting of alfalfa, as compared with the check plot, from 0.56 to 2.98 percent and the phosphorus content from 0.05 to 0.18 percent. On another plot the application of 250

pounds of superphosphate (conc. not given) in addition to 2 tons of limestone per acre gave an additional increase in the phosphorus content to 0.21 percent but the calcium content was only 2.60 percent. Analysis of the second cutting of the check, limestone, and limestone-acid phosphate plots gave 1.52, 1.82 and 1.62 percent calcium and 0.26, 0.25, and 0.31 percent phosphorus respectively.

The absorption of phosphorus may be influenced by the soil reaction. On Cecil sandy loam soil with a pH of approximately 4.5, Moser (19) found that unfertilized soil produced lexpedeza with a phosphorus content of 0.17 percent while an application of 600 pounds of 0-10-0 fertilizer per acre produced lespedeza with a phosphorus content of 0.21 percent. Although the difference in compositional percentage was not great, variations in recovery of phosphorus were 13 and 21 pounds per acre respectively for the unfertilized and fertilized plots. An application of 1200 pounds of 0-10-0 fertilizer to the soil with a pH of 4.5 did not increase the percentage or recovery of phosphorus over that obtained from the 600 pounds application. When the pH was raised to approximately 6.25, the unfertilized lespedeza analyzed 0.22 percent phosphorus and recovered 21 pounds of phosphorus per acre while lespedeza produced at the same pH but fertilized with 600 pounds of 0-10-0 per acre analyzed 0.25 percent phosphorus and recovered 30

pounds of phosphorus per acre. An application of 1200 pounds of 0-10-0 fertilizer per acre to this soil of 6.25 pH produced lespedeza with 0.26 percent phosphorus and increased the recovery of phosphorus to 36 pounds per acre. When the pH was raised to approximately 7.25 and treated under similar conditions as above for the soil of 6.25 pH, the percentage and recovery of phosphorus was lower in each corresponding case.

Exceedingly heavy applications of phosphates are required on certain soils to increase the percentage composition of phosphorus. Bryan and Neal (5) reported that certain soils of Florida appeared to produce "sweeny" in cattle due to the low phosphorus content of the herbage while certain other areas did not produce "sweeny" in cattle grazing on the herbage. The "healthy" soil required applications of phosphates (conc. not given) in excess of 1500 pounds per acre to raise the phosphorus content of vetch above 0.11 percent which was the phosphorus content of the unfertilized herbage. The unfertilized "sweeny" soil produced herbage of 0.08 percent phosphorus and required applications of superphosphate in excess of 2000 pounds per acre to raise the phosphorus content of vetch. Applications of 8000 pounds of superphosphate per acre increased the phosphorus content of vetch grown on the "healthy" soils and the "sweeny" soil to approximately

0.30 and 0.16 percent respectively. When vetch was replaced by sorghum and fertilized in like manner, the phosphorus content of the sorghum was similar to that of vetch for each corresponding case.

The application of phosphates to phosphorus deficient soil, under favorable conditions, usually gives an increase in the total phosphorus content of the plants, although the organic phosphorus content does not appear to be increased to any appreciable extent. Under Michigan conditions, Mathers (15) reported a 100 percent increase in the total phosphorus content of alfalfa due to heavy (1000-2000 pounds of triple superphosphate) applications of fertilizer but that the organic form of phosphorus was increased only as the pounds of hay per acre was increased. He found that applications of 200 pounds of triple superphosphate per acre gave maximum yields of hay and therefore, gave maximum yields of organic phosphorus. Mathers is of the opinion that it is not economical nor desirable to increase the phosphorus content of forage by extremely heavy applications of phosphates.

The application of lime alone to the soil appears to influence the phosphorus composition of plants. Various data indicats that the phosphorus content of the plant is lowered by applications of lime while other published data contradict this information. As stated

previously, Price (22) reported that an application of 2 tons of limestone per acre raised the phosphorus content of the first cutting of alfalfa more than 300 percent but lowered the phosphorus content of the second cutting about 4 percent. Wilkins and Vinall (27) reported that an application of 4 tons of limestone per acre did not influence the percentage composition of phosphorus in pasture herbage but increased the recovery of phosphorus of an average of about 20 percent for the 2 years following the application. Emmert (8) found that the addition of lime alone to the soil caused a decrease in the percent of phosphorus in the plant, but when heavy applications of organic matter was added with the limestone the phosphorus content was increased. Grizzard (9) and Naftel (21) reported that applications of lime alone tended to lower the percent of phosphorus in plants.

Various data indicate that applications of phosphates alone and in combination with other fertilizer elements under natural farm conditions increased the yield of forage crops materially but may or may not increase the percentage composition of phosphorus. An application (13) of 120 pounds of triple superphosphate per acre on the wooded soils of Alberta had little effect on the percent phosphorus in red clover (0.25 vs. 0.24 percent) but increased the yield from 1330 to 3484

pound per acre. Burke, et al.(6), in cooperation with a large number of extension workers and farmers reported that applications, under natural farm conditions in Montana, of 160 pounds of triple superphosphate per acre did not materially influence the protein or calcium content of various hays but increased the phosphorus pentoxide content approximately 18 percent and increased the yield 30 percent. On Puget silt loam soil (25) of Western Washington, an application of 300 pounds of sodium nitrate per acre was the only application of a combination of fertilizer elements to increase the phosphorus content of alfalfa. This application increased the phosphorus content from 0.27 percent for the check plot to 0.32 percent for the plot receiving the nitrate. Applications of 300 pounds of sodium nitrate and 600 pounds of 16 percent superphosphate or 600 pounds of 16 percent superphosphate and 200 pounds of 50 percent potassium chloride or 300 pounds of sodium nitrate, 600 pounds of 16 percent superphosphate and 200 pounds of 50 percent potassium chloride did not increase the phosphorus content of the first cuting of alfalfa over that of 0.27 percent for the check plot.

Austin (1), Burke (6), Sotala (24), Millar (16), and Daniel and Harper (7) reported that the percentage of phosphorus in certain legumes was influenced by applications of phosphorus fertilizers on certain types of soil while

on other types of soil phosphate applications had little or no affect.

While the composition of plants is probably determined to a large extent by their genetic make-up, the above literature shows that variations in plant composition may result from factors such as soil type, fertilizer treatment and various other conditions. With the advance in science, increased effort has been made to determine the influence exerted by these factors on the composition of plants. Due to the various factors operating simultaneously, it has been rather difficult to determine the influence exerted individually by each factor or various combinations of factors as the frequent disagreement between investigators cited above shows.

Summarizing, it seems safe to conclude that; the organic phosphorus content is not materially influenced by light or heavy applications of phosphates while the inorganic phosphorus content of the plant may be increased markedly by applications of 500 to 1000 pounds of 20 percent superphosphate per acre.

The soil reaction influences the rate of reversion of phosphates, percentage composition of phosphorus in plants and total phosphorus removed per unit area by crops. Browne (4) states:

> Usually in cases of deficiency the influence of added phosphate is to increase the percentage of phosphoric acid in the ash and dry matter of the crop, and frequently to produce a decrease in the assimilation of some of the other nutrients, but so much depends upon the character of the soil, crop, climatic conditions, and other factors that no general rule can be stated.

It has been definitely established that certain soils are lacking in available phosphorus and that these soils produce plants that are low in phosphorus content as measured by the phosphorus content of the plants produced on soils with adequate amounts of available phosphorus for maximum plant growth.

Moderate applications of phosphates have increased yield markedly and raised the percentage composition of phosphorus slightly when applied to phosphorus deficient soils. The idea that the mineral composition of plants can be adjusted to a desirable level by supplying the needed mineral or minerals to the soil in the form of a fertilizer has not been proven. The application of mineral fertilizers in excess of that amount required for maximum economical yield, to increase the mineral composition, should be looked on with caution until conclusive experimental studies have been carried out.

PROCEDURE

Selection of Hays

Samples of red clover hays were collected from several farms in East and Middle Tennessee. Most of these samples were collected by Professor Duncan and an effort was made to determine the recent and previous applications of phosphate, soil type, productiveness, and general history of the fields from which the samples were taken for analysis. Data on the fields where the samples were collected are not as complete as is desirable due to various reasons. Several of the owners or operators of the farms were not at home when the samples were collected and as the collection of the samples covered a considerable part of the state, return trips were difficult to make. Also, a few samples were sent in by agricultural workers and all the desired data were not supplied. Fifty-six samples of red clover were collected in East and Middle Tennessee and analyzed for phosphorus in an effort to study the phosphorus content of red clover hays and find suitable hays for use in our project.

After a sample was collected from the field, it was placed in a paper bag and numbered. The samples were later dried in a hot air oven for approximately 24 hours, then ground in a Wiley mill. The total ground sample was

TABLE I

DATA PERTAINING TO HAY SAMPLES ANALYZED FOR PHOSPHORUS CONTENT

No.	Owner	County	Recent phosphate added to field pounds	Previous phosphate added to field pounds	Upland bottom	P %
1	Sharp	Sevier	120 meta	Low	Upland	.10
2	"	"	Check plot	"	"	.19
3	"	"	120 meta	Unknown	"	.19
4	"	"	120 meta	Light	"	.12
5	Henderson	"	200 20%	400 16% every 3 years	Bottom	.14
6	"	"	200 16%, fall 1939	200 spring 1939	Upland	.14
7	Swan	"	125 0-10-4, fall '39	None reported	Bottom	.13
8	Atchley	"	300 0-10-4	450 every 4 years for last 10 years	"	.18
9	G.McMahan	"	200 16%	Light	"	.12
10	E.McMahan	"	150 16%, corn '39 200 16%, wheat '39 100 48%, clover '40	200 16% previous 4 years	Upland	.09
11	E.McMahan	"	150 16%, corn '39 200 16%, wheat '39	200 16% previous 4 years	"	.11
12	Butler	"	None	100 16% each year for 4 years	Bottom	.17
13	"	"	150 16%, wheat 400 basic slag '41	100 16% annually for previous 4 years	"	.14
14	Self	"	100 0-10-4 '39 100 0-10-4, clover	None reported	Upland	.08
15	Lamon	Blount	Moderate	Moderate	"	.13
16	Jackson	"	Heavy	Light	"	.09
17	U.T.Farm	Knox	"	Heavy	"	.22

TABLE I

DATA PERTAINING TO HAY SAMPLES ANALYZED FOR PHOSPHORUS CONTENT (Contd.)

No.	Owner	County	Recent phosphate added to field pounds	Previous phosphate added to field pounds	Upland bottom	P %
18	R & W	Jefferson	Unknown	Unknown	Bottom	.13
19	Dagland	"	"	"	Upland	.16
20	Estes	"	125 16%, wheat '39 75 16%, clover	Light since '33	Unknown	.11
21	Denton	"	100 16%, wheat '39 100 20%, clover '40	100 16% 5 years ago	Upland	.09
22	Harper	"	200 16%, barley 125 16%, clover	300 on alfalfa 5 years ago	"	.10
23	Walker	"	300 triple super.	Light	"	.20
24	"	"	300 triple super. 200 triple super. '39	None reported	"	.17
25	Shrader	"	150 16%, wheat 150 16%, clover	Very little	Bottom	.11
26	Hance	"	160 0-10-4, wheat	Light	"	.09
27	Reece	"	100 45% & 100 0-10-4, wheat. 200 45%, clover	None reported	Upland	.10
28	"	"	125 0-10-4 & 100 45%, barley	" "	"	.14
29	Miller	"	125 0-104; 200 45%	None	"	.10
30	Fox	"	125 45%	None reported	"	.12
31	C.N.Farm	"	(omitted due to immaturity of sample)			
32	C.N.Farm	"	150 16% '40	None reported	"	.09
33	M.T.E.Sta.	Maury	None	None	"	.29
34	Smithson	"	"	"	"	.14
35	Whitt	"	"	"	"	.14

TABLE I

DATA PERTAINING TO HAY SAMPLES ANALYZED FOR PHOSPHORUS CONTENT (Contd.)

No.	Owner	County	Recent phosphate added to field pounds	Previous phosphate added to field pounds	Upland bottom	P %
36	Owen	Maury	None	None	Upland	.19
37	Meacham	"	"	"	Unknown	.16
38	Green	Williamson	125 43%	"	"	.22
39	King	"	None	"	"	.26
40	Dement	Rutherford	100 43% Aug. '40	"	"	.13
41	Adams	Bedford	None	"	"	.25
42	"	"	"	"	"	.21
43	Parkes	Moore	"	"	"	.13
44	Brandon	"	"	"	Bottom	.22
45	Siveley	"	"	"	Unknown	.17
46	Evans	"	"	"	Bottom	.19
47	Hardwick	Bradley	Liberal	Liberal	Upland	.18
48	Buttrey	Williamson	200 triple '39	None	Unknown	.10
49	Meacham	"	None	300 triple '35	"	.15
50	Keefauver	Washington	Unknown	Unknown	"	.20
51	Denton		(check on sample 21)			.09
52	Dement	Bedford	None	None	"	.16
53	W.Molder	"	"	"	"	.15
54	E.Molder	"	"	"	"	.22
55	Turentine	"	80 triple	"	"	.15
56	Lowe	"	None	"	"	.21

thoroughly mixed and enough taken from it to fill a small mason jar. Part of the hay in this jar was used for the analysis of phosphorus and the remainder kept in storage for future analysis, if needed. Some of the data assembled relating to the hay samples are given in Table I.

Some of the samples analyzed are of particular interest. In 1940 (Table II) a sample from Hugh Henderson's farm analyzed 0.16 percent phosphorus. Two samples were collected this year from his farm in Sevier County (Table I). Although, the two samples that were collected this year were from different sections of the farm, they analyzed 0.14 percent phosphorus each. One sample was taken from bottom land that had received 200 pounds of 20 percent superphosphate per acre on wheat in the fall of 1939. Previously to this it had received 400 pounds of 16 percent superphosphate per acre every three years for the past decade. This bottom had been lightly limed in 1935. No record of any manure applications were reported. The other sample was grown on upland on Henderson's farm. This field received 200 pounds in the spring and 200 pounds in the fall of 16 percent superphosphate per acre in 1939. The field was in grass and clover from 1936 to 1939.

Two samples were selected within 30 feet of each other in the same field on Ernest McMahan's farm in

Sevier County. This field received 150 pounds of 16 percent superphosphate on corn and 200 pounds of 16 percent superphosphate per acre on wheat in 1939. In the four previous years, the field had received 200 pounds of 16 percent superphosphate per acre. Clover was seeded in the wheat in the spring of 1939. In the fall of 1940, part of the clover on this field received 100 pounds of 48 percent superphosphate per acre. The clover on this area made a good growth but the sample taken from this part contained only 0.11 percent phosphorus. The sample taken within 30 feet of this sample and from the part of the field not receiving the phosphate application in the fall of 1940 contained 0.09 percent phosphorus. The clover growing in the old corn rows was distinctly heavier in growth than clover growing between the rows in this area. This heavier growth was probably due to the residual effect of the phosphate applied in the corn rows in 1939. The part of the field receiving the application of phosphate on the clover in the fall of 1940 appeared to be producing more than three times as much hay per acre as compared with that part of the field not receiving the application of phosphate on the clover in the fall of 1940. This application of 100 pounds of 48 percent phosphate increased the yield of hay-phosphorus materially per acre but raised the phosphorus content of the hay only 0.02 percent.

Two samples were collected from the County Poor Farm in Jefferson County. One field of upland branch bottom had been in corn for two years previously to barley, sown in the fall of 1939. Three hundred pounds of triple superphosphate was applied per acre when the barley was sown. This sample contained 0.20 percent phosphorus. A sample taken from another field, contained 0.17 percent phosphorus. This field received 200 pounds of triple superphosphate per acre on corn in 1939 and 300 pounds of triple superphosphate per acre on wheat in the fall of that year. No application of phosphate was made when the clover was sown. This field was manured twice during the last two years. The second field was in lespedeza for two years, following wheat in 1936 that received 300 pounds of triple superphosphate per acre. Corn on this field in 1935 received 450 pounds of 16 percent phosphate per acre and produced 25 bushels per acre. In 1931 this field was in pasture that was composed largely of sassafras and redtop. These samples were both considerably above the average for upland red clover of that section. The liberal applications of concentrated phosphate fertilizer may have been responsible for this condition.

The hay selected as the "average" (0.20% P) phosphorus hay for this year's experiment was obtained

from S. L. Atchley (Table I) in Sevier County. This hay was grown on good Pigeon river bottom land near the mouth of the river. An application of 300 pounds of 0-10-0 fertilizer had been made on the wheat crop previously to sowing the red clover. Four hundred fifty pounds of superphosphate had been applied to this land every four years for the last ten years. The land had been limed (4 tons per acre) and partly manured. This land produced about 50 bushels of corn per acre. The rotation for the past several years had been corn-corn-wheat-clover.

The hay purchased was baled from the barn. Due to being cured in the barn the hay had a brown color, although, in all other respects it was of excellent quality. No moldy hay or foreign material was found in the hay while it was being ground. There was a high proportion of leaves to the amount of stems and the aroma of the hay was sweet.

The "low" (0.10 % P) phosphorus hay used in this year's work was purchased from J. H. Denton of Jefferson County. The total known phosphate applied to this land was 100 pounds of 20 percent superphosphate on the clover in the spring of 1942, 100 pounds of 16 percent on wheat in the fall of 1939 and 100 pounds of 16 percent superphosphate over a period of four years prior to 1939.

In the past 10 years the land has been limed with 2 tons of lime per acre and has also received some manure. The field producing the purchased hay was badly galded and eroded as recent as six years ago. At present, the gullies have been plowed in and the land is on the upgrade.

The hay was of a medium maturity when cut and retained a good green color, being baled directly from the field with a pickup baler. The leaves disintegrated in the bale due to baling while the hay was dry. There may have been a slight loss of leaves in baling. This hay had some undesirable foreign material of which corn stalks made up the greater part. Care was exercised to remove these stalks while grinding the hay. No moldy hay was found at any time and the aroma was sweet.

Several cases were found where liberal applications of phosphate had been made but the hay produced on the land was below average in phosphorus content (Table I, Samples Nos. 10, 11, 13, 22, and 27). These samples indicate that the application of phosphate in liberal amounts to land is no assurance that the land will produce red clover hay of desirable phosphorus content. Also, there are indications that land in the phosphorus deficient areas of Tennessee can be so managed that good quality hay will be produced (Table I, Samples Nos. 8, 12, 17, 23, 47, and 50). Several samples were analyzed from

both upland and bottom land that produced "better-than-average" hay in phosphorus content. Some of these same farms were in a relative low state of cultivation a few years ago (Table I, Samples Nos. 17, 23, 24 and 27). The production of good quality red clover hay in the phosphorus deficient areas of Tennessee appears to require more than just an application of phosphate. It is indicated by this small amount of data that applications of phosphate must be coordinated with other good farming practices to produce the desired high quality hay.

The analytical work done during the three years appear to indicate that the phosphorus content of red clover hays produced on the same farms tend to be nearly constant (Table II) over a period of years.

TABLE II

PHOSPHORUS CONTENT OF HAY SAMPLES COLLECTED FROM THE SAME FARM FOR TWO OR MORE YEARS.

Owner	County	1939 (3) Percent	1940 (14) Percent	1941 Perc.	Average Perc.
W. M. Brandon	Moore	---	.24	.23	.24
G. Dagland	Jefferson	.17	.14	.16	.16
M.T.Expt.Sta.	Maury	.31	---	.29	.30
G.McMahan	Sevier	.12	---	.12	.12
H.Henderson	Sevier	---	.16	.14	.15
U.T. Farm	Knox	.16	.19	.22	.19
Average		.19	.18	.19	.19

This year's analysis indicates that certain counties of Middle Tennessee produce red clover hay that has approximately one-third more phosphorus than similar samples collected in counties of East Tennessee (Table III).

TABLE III

AVERAGE PHOSPHORUS CONTENT OF HAY SAMPLES FROM COUNTIES WHERE FOUR OR MORE SAMPLES WERE COLLECTED

County	No. of samples	Average P content %	Division of State	
			Middle %	East %
Sevier	14	.13	- - -	.13
Jefferson	14	.13	- - -	.13
Williamson	5	.19	.19	- - -
Bedford	7	.19	.19	- - -
Moore	4	.18	.18	- - -
Average		.15	.19	.13

Experimental Animals.

Sixteen grade calves of beef type were bought on the Knoxville Auction Market. These calves were selected for uniformity in weight, condition, age, type and grade. Calves of the type desired were scarce on the Knoxville Auction Market in August and early September at the time of purchase and several trips to the auction ring were necessary to obtain the desired number of calves.

Each week as calves were purchased they were placed on a ration composed of approximately 3 parts of ground

low phosphorus hay and one part yellow corn meal. No record of feed consumption was kept until all calves had been obtained and placed on a preliminary low phosphorus ration. After all calves were obtained, they were tagged, treated for hemorrhagic septicemia, castrated and placed on the preliminary ration. The calves were fed 6 pounds daily of a mixture of 3 parts of the low phosphorus experimental hay and 1 part of yellow corn meal with salt and water ad lib. A few calves failed to consume all feed planned in the ration of 6 pounds daily for the 32 day preliminary feeding period.

At the end of the preliminary period the calves were weighed and the blood phosphorus content determined. Table IV gives the weight, grade and condition of the calves as they were divided into lots at the beginning of the experiment.

TABLE IV

WEIGHT, CONDITION AND FEEDER GRADE OF ANIMALS BY LOTS AT THE BEGINNING OF THE EXPERIMENT

Lot No.	Calf No.	Weight	Feeder Grade	Condition
I	775	346	Medium good	Medium
	761	377	High medium	Medium
	764	348	Low good	Low medium
	769	407	Medium good	Medium
Average		370		
II	770	400	High good	Fat
	772	305	High medium	Medium
	771	384	High medium	Medium
	760	364	Low good	Medium
Average		363		
III	765	382	Low good	Medium
	773	349	Low good	Medium
	766	413	Medium good	Medium
	774	329	High medium	Medium
Average		368		
IV	767	331	High medium	Medium
	763	365	Low good	Low Medium
	768	382	High medium	Low medium
	762	383	Low good	Low medium
Average		366		

Rations.

The rations of Lots I and II were set-up to study the effect on beef calves of a ration containing red clover hay of a low phosphorus content as compared with a ration containing red clover hay of average phosphorus content. The roughage of Lot I was composed of ground low phosphorus (0.10%) red clover hay while that of Lot II was composed of ground average phosphorus (0.20%) red clover hay. The rations of Lots I and II differed only in the quality of red clover hay used. Besides the variation in phosphorus percentage of the two hays, there was a variation of 36 percent in the protein, 34 percent in the calcium, and 12 percent in the N-free extract as is shown in Table V.

TABLE V

COMPOSITION OF HAYS AND CORN MEAL USED

	Low P hay (0.10%) Percent	Av. P hay (0.20%) Percent	Corn Meal Percent
Moisture	9.69	10.56	10.23
Ash	4.74	5.95	1.26
Crude fat	4.25	4.38	4.14
Crude fiber	25.07	22.07	2.06
Protein (N X 6.25)	9.36	14.61	9.65
Calcium	1.37	2.09	0.03
Phosphorus	0.10	0.20	0.25
N-free ext.(by dif	45.42	40.14	72.38
Total	100.00	100.00	100.00

The calves were fed individually at regular hours twice daily. Feed refused by any animal was weighed and recorded. It was planned at the first of the experiment to give all calves 8 pounds of feed daily with an increase later as needed. Consumption by all lots was fairly uniform for the first two periods (see Table XII). At the end of the second period it was decided to feed the calves 9 pounds each daily except in cases where calves refused part of the feed. The calves of Lot I consistently refused part of their feed after the second period. These calves were fed at all times as much as they would eat, that is, up to 9 pounds daily. Failure to consume 9 pounds daily was due to lack of appetite and not to lack of feed supplied as is shown in Table XII. Calves that failed to consume a large part of their feed were fed about one pound more daily than they would clean-up.

The rations of Lots III and IV were planned to study the influence of adding a liberal phosphorus supplement to the basal rations used for Lots I and II. Rations for Lots I and III differed only in that dicalcium phosphate was supplied to Lot III; also, rations for Lots II and IV differed only in that dicalcium phosphate was supplied in Lot IV. The percentage of the nutrients used in the rations for the various Lots is given in Table VI.

TABLE VI

SHOWING AMOUNT, DIGESTIBLE PROTEIN, TOTAL DIGESTIBLE NUTRIENTS AND NUTRITIVE RATIOS OF THE RATIONS AS PLANNED ON AN 8 POUNDS PER DAY BASIS

Feed	Amount		Digestible protein	Total digestible nutrients	Nutritive ratio
	Per-cent	pounds	pounds	pounds	
R.clover hay (.10%)	74.50	5.96	0.33	3.29	
Corn meal	24.25	1.94	0.11	1.63	
Salt (NaCl)	1.00	0.08			
Cod liver oil	0.25	0.02			
Lot I. Total	100.00	8.00	0.44	4.92	1:10.2
R.clover hay (.20%)	74.50	5.96	0.51	3.18	
Corn meal	24.25	1.94	0.11	1.63	
Salt (NaCl)	1.00	0.08			
Cod liver oil	0.25	0.02			
Lot II. Total	100.00	8.00	0.62	4.81	1:6.6
R.clover hay (.10%)	74.50	5.96	0.33	3.29	
Corn meal	23.25	1.86	0.11	1.66	
Salt (NaCl)	1.00	0.08			
Cod liver oil	0.25	0.02			
Dicalcium phosphate	1.00	0.08			
Lot III. Total	100.00	8.00	0.44	4.95	1:10.1
R.clover hay (.20%)	74.50	5.96	0.51	3.18	
Corn meal	23.63	1.89	0.11	1.59	
Salt	1.00	0.08			
Cod liver oil	0.25	0.02			
Dicalcium phos.	0.62	0.05			
Lot IV. Total	100.00	8.00	0.62	4.77	1:6.6
Morrison's feeding standard for wintering beef calves to gain 0.75 to 1.00 lb. per head daily. Weight 400 lbs.			0.63-0.70	4.8-5.7	1:6.7-7.2

TABLE VII

AVERAGE DAILY RATIONS CONSUMED BY LOTS FOR 168 DAYS

Feed	Amount		Digestible protein	Total digestible Nutrients	Nutritive ratio
	per-cent	pounds	pounds	pounds	
Lot I					
R.clover hay	74.50	5.35	0.28	2.95	
Corn meal	24.25	1.74	0.11	1.46	
Salt (NaCl)	1.00	0.07			
Cod liver oil	0.25	0.02			
Total	100.00	7.18	0.39	4.41	1:10.2
Lot II					
R. clover hay	74.50	6.39	0.55	3.41	
Corn meal	24.25	2.08	0.13	1.75	
Salt (NaCl)	1.00	0.09			
Cod liver oil	0.25	0.02			
Total	100.00	8.65	0.68	5.16	1:6.6
Lot III					
R. clover hay	74.50	6.33	0.35	3.49	
Corn meal	23.25	1.97	0.12	1.63	
Salt (NaCl)	1.00	0.09			
Cod liver oil	0.25	0.02			
Dicalcium phos.	1.00	0.09			
Total	100.00	8.50	0.47	5.12	1:10.0
Lot IV					
R. clover hay	74.50	6.46	0.56	3.45	
Corn meal	23.63	2.05	0.13	1.72	
Salt (NaCl)	1.00	0.09			
Cod liver oil	0.25	0.02			
Dicalcium phos.	0.62	0.05			
Total	100.00	8.67	0.69	5.17	1:6.6

Morrison's digestion coefficients were used to obtain the digestible nutrients of the feeds used. In comparing the digestible nutrients and nutritive ratios of the various rations it should be kept in mind that these values are only approximately correct, as the actual digestion coefficients for the various feeds used were not determined in the experimental procedure. That is, we do not have any more reason to believe that the digestion coefficient for the protein content of red clover hay is any more a constant than the protein content itself is a constant.

As is shown in Table V, the crude protein content of the low phosphorus hay is 9.36 percent which is below the average figure given by Morrison of 11.8 percent for "all analyses". The total digestible nutrients actually consumed by Lots II, III, and IV (Table VII) are within the range as given by Morrison for wintering 400 pound calves to gain 0.75 to 1.00 pound per head daily. Due to lack of consumption, the calves of Lot I did not receive the total digestible nutrients required to gain 0.75 to 1.00 pound per day. The total protein consumed and the nutritive ration of Lots II and IV were favorable for normal growth. As compared with Morrison's standards, the total protein consumed by Lots I and III was not enough to support a growth of 0.75 to 1.00 pound per day

per animal. Due to the low protein content of the low phosphorus hay, the nutritive ratios of the rations for Lots I and III were wide.

The data in Table VII and the growth made by the calves fed those rations indicate that so-called balanced rations based on Morrison's standard will not always give satisfactory results. The rations fed Lots II and IV met Morrison's standard in all respects, yet the average gain in weight of both lots remained below the minimum rate that he states they should have attained.

CRITERIA FOR JUDGING RESULTS

Weights and Body Measurements

At the end of each 28-day period the calves were weighed and measurements made for height at withers and for circumference at hearth girth. These measurements were made on the 27th and 28th days of each period and the averages were taken as representing the correct measurements.

Blood Analysis.

Blood samples were taken on the 27th and 28th days of each period when the calves were weighed. A composite sample of the blood was analyzed for the phosphorus content by the Youngburg and Youngburg Method.

Economical Aspect of Low Phosphorus and Average Phosphorus red clover hays for wintering growing calves.

A complete record was kept of the feed consumed and refused by each individual animal. Feed consumption and feed cost per 100 pound gain was obtained for the various lots.

Pictures and Observations.

Pictures of the individual calves were taken at the beginning and at the end of the experiment. These pictures were made against a charted background and shows the growth made by each calf.

RESULTS

A Comparison of Feeding Value of a Red Clover Hay of a Good Average Phosphorus Content with One of Low Phosphorus Content, as the Roughage in a Wintering Ration for Growing Calves.

Weights and Body Measurements.

The rations for Lots I and II were designed to compare the feeding value of a red clover hay of a good average phosphorus content with one of low phosphorus content, as the roughage in a wintering ration of growing calves. There was not a great amount of difference in gain in weight of the animals in Lots I and II for the first period. At this time the calves of Lot I had been on a low phosphorus ration more than 60 days (Preliminary period and 1st 28-day period). After the first period the calves of Lot I failed to show any gain in weight for the next 3 periods while Lot II gained an average of 41 pounds each in the same period of time. Gain in weight by 28-day periods is shown in Table VIII and Figure I.

The average gain in weight for calves of Lot I was only 35 percent as much as the average gain for calves in Lot II. The average gain in heart girth for Lot I was 56 percent as great as that made by Lot II while the gain in height at withers for Lot I was 93 percent as great as that made by Lot II.

TABLE VIII

GAIN IN WEIGHT BY 28-DAY PERIODS

Calf No. / Lot No.	Period						
	1	2	3	4	5	6	Total
775	16	11	-8	-1	4	-2	20
761	25	-4	3	0	5	3	33
I 764	24	-21	1	12	20	13	29
769	21	5	-2	15	12	10	61
Total	86	-9	-6	16	42	14	143
Average	21.50	-2.25	-1.50	4.00	10.50	3.50	35.75
770	17	-16	19	14	26	31	91
772	42	13	37	32	22	0	146
II 771	28	12	33	15	21	12	121
760	23	-8	-1	11	13	10	48
Total	101	1	88	72	82	53	406
Average	27.50	0.75	22.00	18.00	20.25	13.50	101.50
765	24	-15	-2	8	27	9	51
773	27	6	22	17	9	27	108
III766	21	8	-27	21	16	25	64
774	25	8	24	18	23	37	135
Total	97	7	17	64	75	98	385
Average	24.75	1.75	4.25	11.00	18.75	24.50	89.50
767	24	3	20	1	33	21	102
763	31	13	42	11	25	30	152
IV768	18	4	29	12	18	14	95
762	33	-6	25	5	6	24	87
Total	106	14	116	29	82	89	436.00
Average	26.50	3.50	29.00	7.25	20.50	22.25	109.00

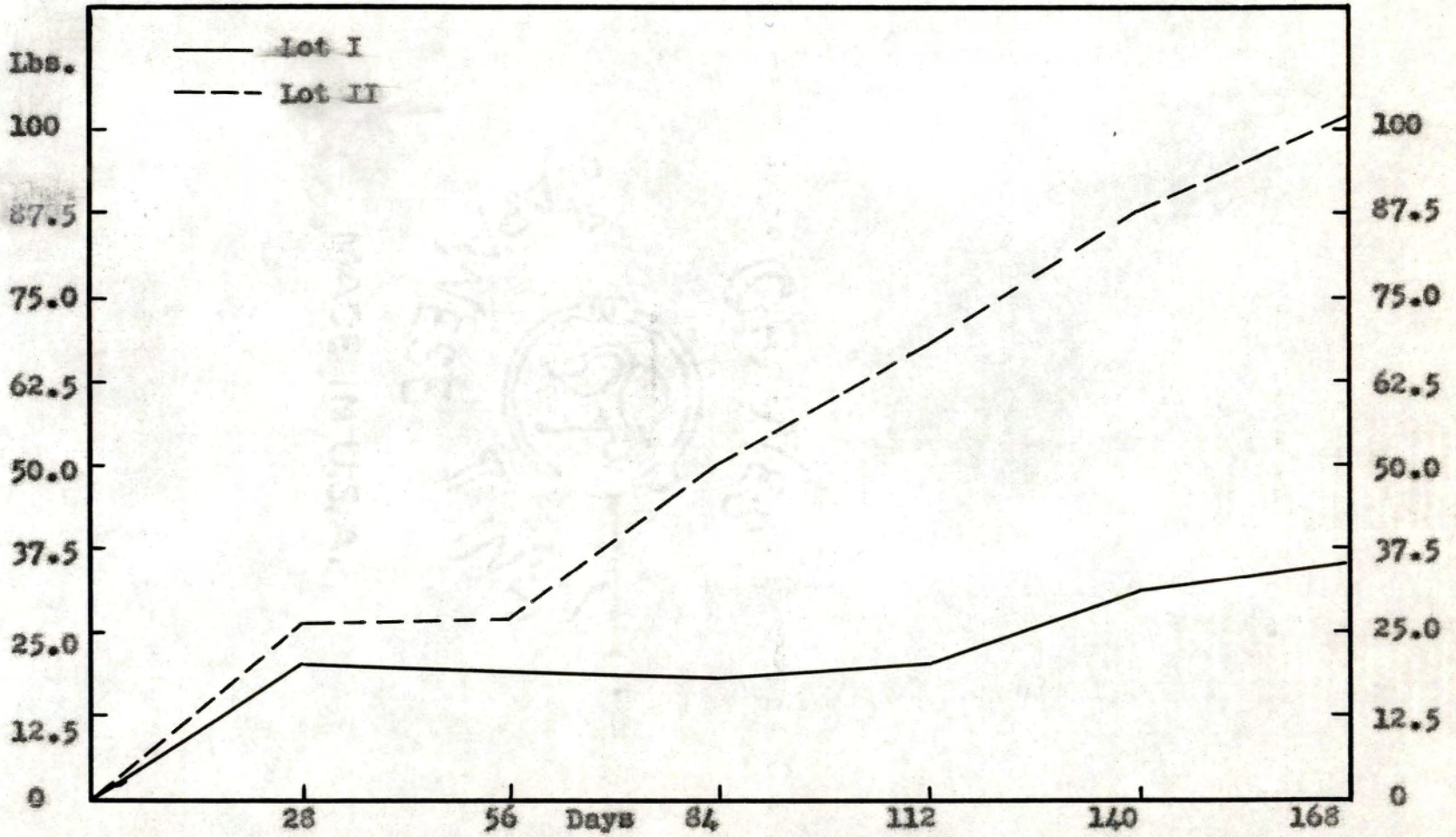


Figure I. Gain in weight by Lots I and II by 28-day periods

Average gain in heart girth for the individual animals is shown in Table IX and Figure 2. It will be noted that the average gain made by Lot I is considerable below that for any other lots. Gains in heart girth are somewhat similar to the respective gains in weight by the various lots.

TABLE IX

AVERAGE AND INDIVIDUAL GAINS IN HEART GIRTH BY 28-DAY PERIODS

Calf & Lot No.	Period						
	1	2	3	4	5	6	Total
775	0.71	0.75	0.04	-0.29	0.25	0.91	2.37
761	0.53	-0.50	0.63	0.38	-0.75	0.87	1.17
I 764	-0.15	0.35	-0.38	0.50	0.75	0.33	1.30
769	0.71	1.25	-0.01	0.13	1.25	-0.09	3.24
Average	0.46	0.44	0.07	0.18	0.37	0.51	2.03
770	1.50	-0.50	0.75	-0.25	0.50	1.41	3.41
772	1.25	0.63	1.62	1.25	1.00	0.75	6.50
II771	0.71	0.63	-0.08	0.71	0.12	1.33	3.42
760	0.42	-0.37	-0.51	0.51	0.87	0.08	1.00
Average	0.97	0.10	0.44	0.55	0.62	0.89	3.60
765	0.08	1.00	-0.88	1.51	0.37	0.55	2.63
773	1.42	1.25	0.50	0.38	-0.05	1.00	4.50
III766	1.84	0.00	-0.38	1.26	0.12	0.83	3.67
774	1.17	0.50	1.00	1.13	1.25	1.04	6.09
Average	1.13	0.69	0.06	1.07	0.42	0.86	4.23
767	0.38	1.37	1.00	0.13	0.87	0.83	4.58
763	1.08	1.00	1.12	1.01	0.12	2.17	6.50
IV768	0.37	0.38	1.50	0.00	1.13	0.45	3.83
762	0.17	1.25	1.58	0.22	0.81	0.90	3.93
Average	0.50	1.00	1.28	0.22	0.81	0.90	4.71

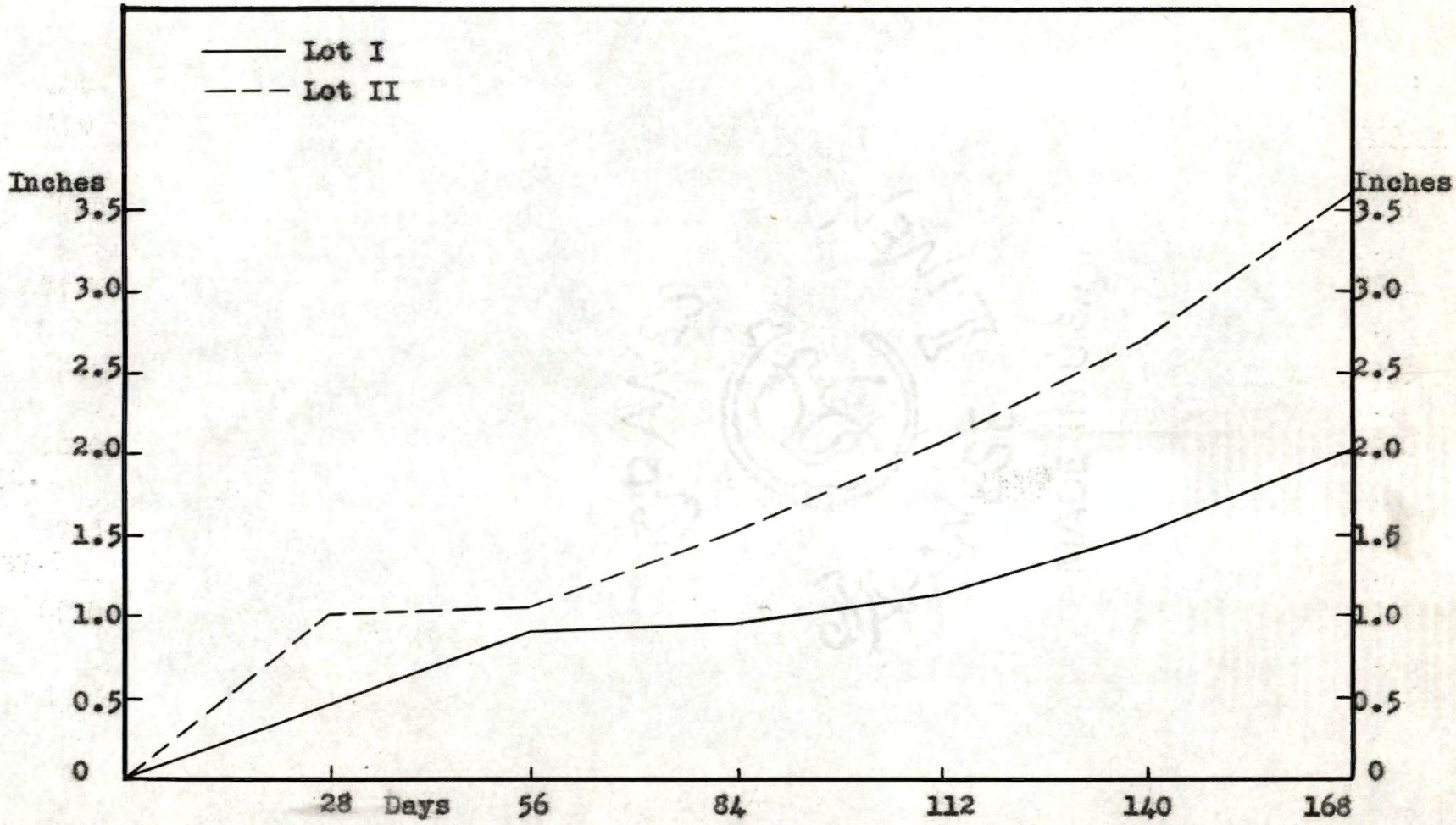


Figure 2. Gain in heart girth by Lots I and II by 28-day periods

Gain in height was more uniform over the entire experimental period than any other measurement. The initial height was 37.2 and 37.1 inches for Lots I and II respectively while at the end of the experiment the height at the withers was 40.6 and 41.1 inches for Lots I and II respectively. The gains in height at withers are shown in Table X and Figure 3.

TABLE X

AVERAGE GAIN IN HEIGHT AT WITHERS BY 28-DAY PERIODS

Calf & Lot No.	Period						
	1	2	3	4	5	6	Total
775	1.05	-0.13	0.75	1.00	0.25	0.83	3.75
761	1.21	0.37	0.00	0.25	0.25	0.92	3.00
I 764	1.46	0.25	0.49	0.51	0.25	1.00	3.66
769	1.13	0.25	0.62	0.50	0.25	0.07	3.75
Average	1.21	0.23	0.58	0.56	0.25	0.86	3.70
770	1.30	-0.13	1.42	0.21	0.12	1.75	4.67
772	1.07	0.62	0.62	0.88	1.12	0.16	4.48
II 771	0.71	0.62	0.25	0.50	-0.25	1.91	3.76
760	1.21	0.25	0.12	0.38	0.50	0.66	3.12
Average	1.07	0.34	0.60	0.49	0.38	1.12	4.01
765	1.71	0.38	0.37	0.63	0.37	1.21	4.66
773	1.42	0.38	0.62	1.25	-0.37	0.95	4.75
III 766	1.87	0.25	-0.25	0.50	1.00	1.08	4.45
774	1.55	-0.13	0.62	1.63	0.88	0.37	4.92
Average	1.64	0.22	0.34	1.00	0.47	0.90	4.56
767	1.63	0.12	0.00	0.63	0.87	0.67	3.92
763	1.67	0.12	0.49	1.51	0.37	1.08	5.17
IV 768	1.20	0.31	0.69	0.51	1.25	0.17	4.13
762	1.67	0.31	0.50	0.50	1.00	-1.00	3.25
Average	1.51	0.22	0.50	0.79	0.87	0.23	4.12

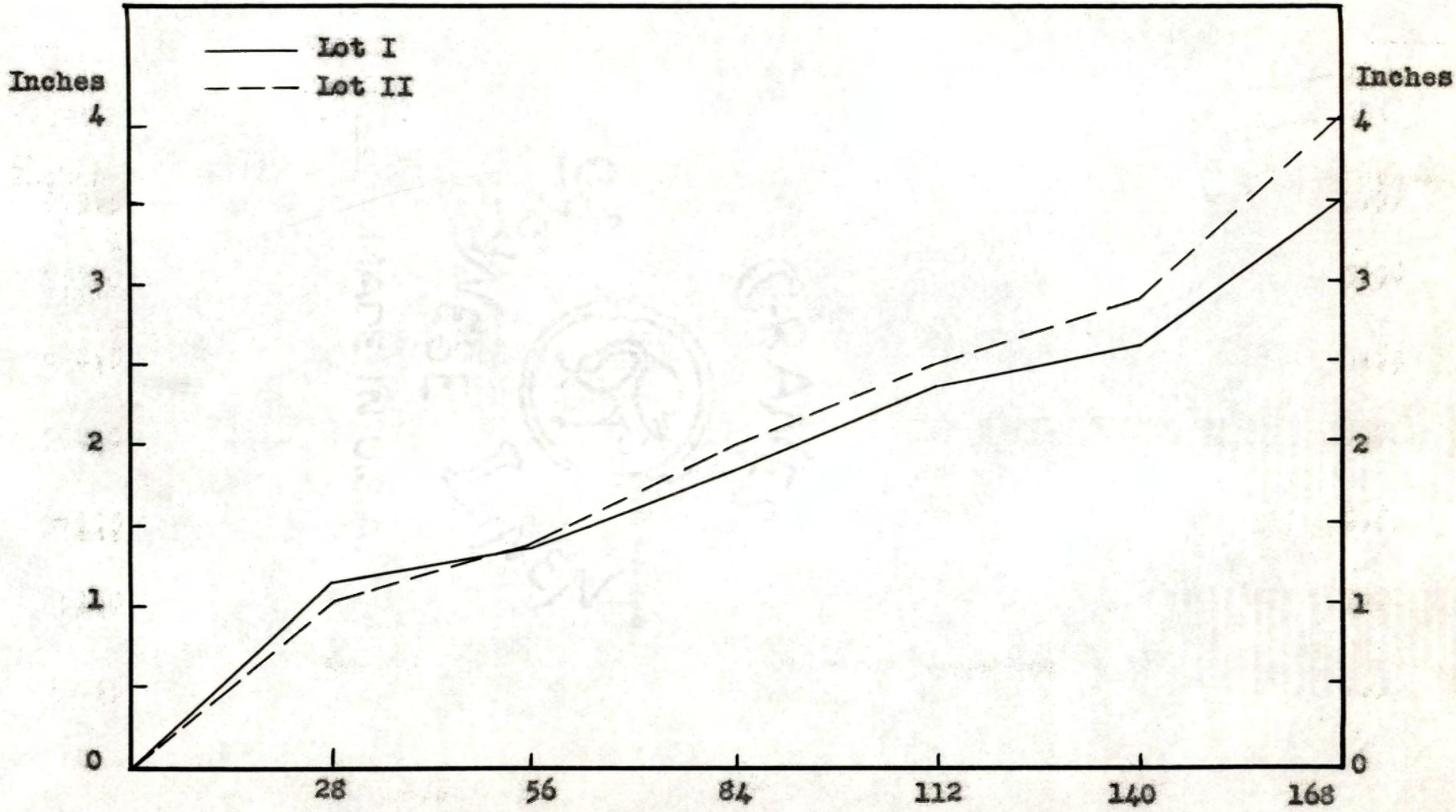


Figure 3. Gain in height at withers for Lots I and II by 28-day periods

Blood Analysis.

Blood analysis was made for the inorganic phosphorus content by the Youngburg and Youngburg Method. Average and range of inorganic blood phosphorus content as shown in figures 4, 17, and 26 were based on data published by S. R. Johnson (11). He found calves ranging in age from 8 to 13 months, average age of 9.8 months, had a mean inorganic phosphorus blood content range of 5.2 to 7.1 mg. per 100 ml. of whole blood with an average of 6.0 ml.

Due probably to the feeding of a preliminary ration low in phosphorus at the beginning of the experiment, both lots were below what Johnson considered normal for 8 to 13 month old calves. Soon after the experiment was begun, the blood phosphorus content of animals in Lot II increased, remaining slightly below the average but well within the range as set out by Johnson. The blood phosphorus content of animals in Lot I remained considerably below the minimum range of 5.2 mg. per 100 ml. of whole blood as is shown in Figure 4. A loss in weight by the calves was frequently accompanied by a temporary gain in the blood phosphorus content. At the end of the second period the blood phosphorus content average for the four lots was the highest during the experiment while during this second period the gain in weight was the lowest.

Table XI shows the blood phosphorus content for the individual calves in the 4 lots. Figure 4 shows graphically the blood phosphorus content for Lots I and II. It will be noted that the blood phosphorus content for Lot I remains consistently below the minimum blood phosphorus range while that for Lot II remains below the average but well within the normal range.

TABLE XI

BLOOD PHOSPHORUS CONTENT. Mg. Per 100 Ml. OF WHOLE BLOOD

Lot & Calf No.	Days						
	Beg.	28	56	84	112	140	168
I 775	3.54	3.81	5.40	3.34	3.82	3.72	3.49
I 764	3.92	4.52	5.45	4.20	4.76	4.46	4.68
I 761	4.42	4.42	6.61	4.89	4.58	4.09	3.83
I 769	4.48	4.26	5.37	4.78	4.08	3.95	4.19
Average	4.09	4.25	5.71	4.30	4.31	4.05	4.05
II 770	3.32	5.44	5.59	5.27	6.35	5.64	5.74
II 772	3.25	5.79	5.77	5.18	5.08	4.55	5.61
II 771	3.52	4.85	6.39	4.85	5.00	5.64	4.88
II 760	4.76	5.90	6.46	5.38	5.32	5.26	5.53
Average	3.71	5.25	6.06	5.14	5.44	5.27	5.34
III 765	3.17	5.49	5.70	5.95	5.47	5.70	7.75
III 773	3.29	4.60	5.34	5.47	5.55	5.59	5.89
III 766	3.97	5.72	5.33	6.16	6.16	6.76	6.39
III 774	3.63	5.65	6.54	6.21	6.25	6.03	6.74
Average	3.59	5.37	5.98	5.95	5.86	6.02	6.19
IV 767	3.73	6.50	6.58	6.45	6.67	5.54	6.76
IV 763	3.64	5.22	6.10	6.36	6.01	5.71	6.06
IV 768	3.52	5.43	6.12	5.31	6.22	5.46	6.17
IV 762	4.27	5.88	6.27	6.18	7.63	6.94	7.38
Average	3.79	5.76	6.27	6.00	6.63	6.16	6.59

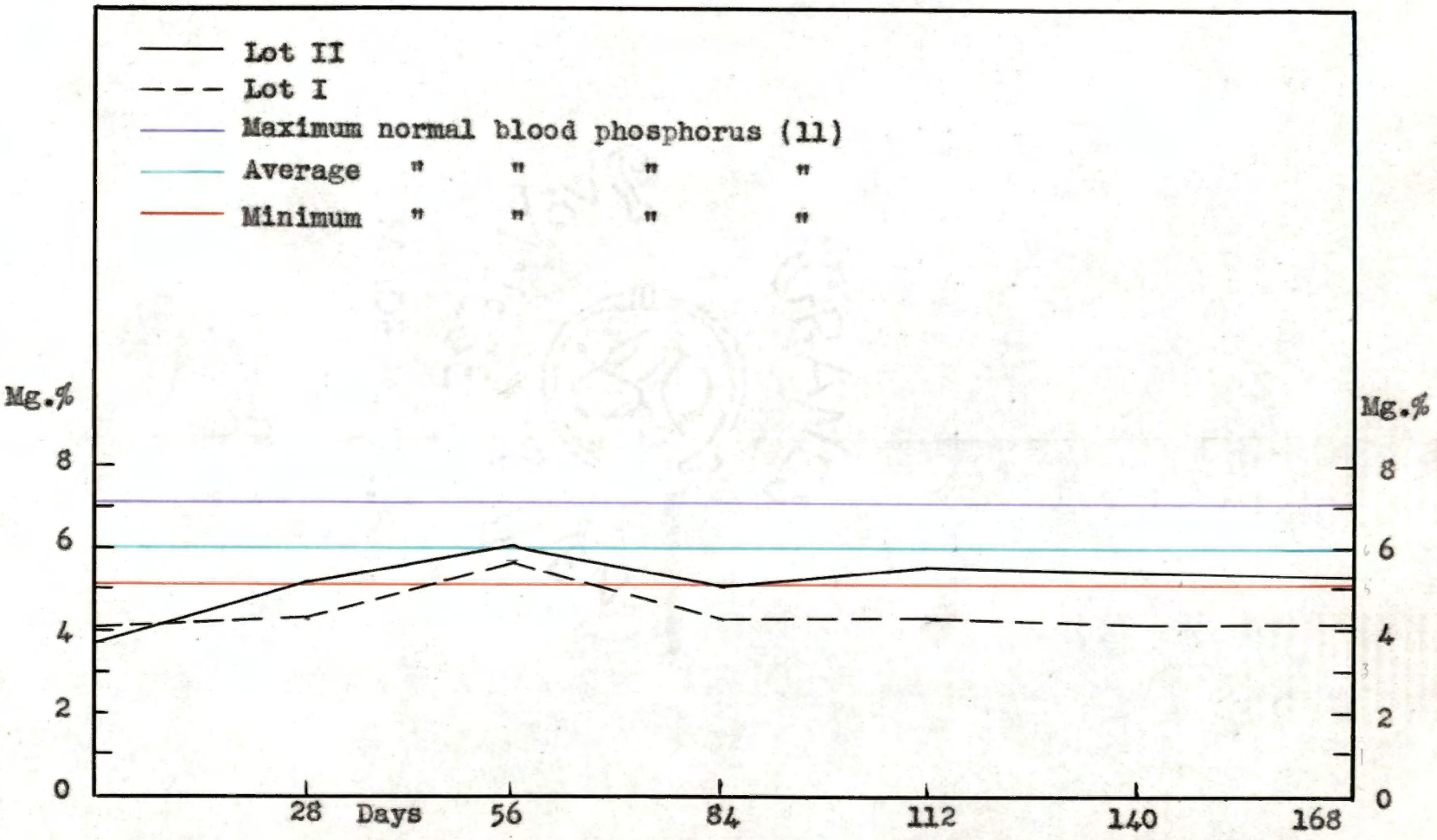


Figure 4. Blood phosphorus - Mg. per 100 Ml. whole blood

Economical Aspect of Low and Average Phosphorus Red Clover Hays for Wintering Growing Calves.

There was little difference in winter feed cost of the two lots on a per animal basis, but the cost per 100 pounds gain markedly favored Lot II. Considerable feed was lost by Lot I due to the almost constant refusal (see Table XII) of part of the feed for the last four periods. Only feed consumed is considered in Table XIII in calculating the winter feed cost of the calves. The amounts of phosphorus as planned in the rations and a s actually consumed by periods are shown in Figure 5. It will be noted in Figure 5 that Lot I consumed considerably less phosphorus than was planned in the ration.

Pictures and Observations.

Pictures against a graphed background were made of the calves of Lots I and II. These pictures were made at the beginning and end of the experiment.

All animals of Lots I and II continued to eat wood shavings, chew the wood of their stalls and show a general depraved appetite. No swelling of joints, lameness or other signs of malnutrition were noticed in any animals in either of the Lots. All calves in these lots had bright eyes and nice coats of hair at the end of the experiment. Figures 7 to 13 inclusive shows the pictures of the calves of Lots I and II.

TABLE XII. AMOUNT OF FEED CONSUMED, FED AND REFUSED FOR 168-DAY PERIOD

P.	Lot I Calf 761			Lot II Calf 760			Lot III Calf 773			Lot IV 762		
	Cons.	Ref.	Fed	Cons.	Ref.	Fed	Cons.	Ref.	Fed	Cons.	Ref.	Fed
1	215.0	0.5	215.5	215.5	0.0	215.5	214.4	1.1	215.5	215.5	0.0	215.5
2	224.0	0.0	224.0	220.7	3.3	224.0	224.0	0.0	224.0	224.0	0.0	224.0
3	213.4	38.6	252.0	232.7	19.3	252.0	252.0	0.0	252.0	252.0	0.0	252.0
4	202.2	31.8	234.0	232.4	19.6	252.0	252.0	0.0	252.0	252.0	0.0	252.0
5	180.7	24.8	205.5	214.3	35.2	249.5	252.0	0.0	252.0	252.0	0.0	252.0
6	206.5	31.5	238.0	241.3	10.7	252.0	252.0	0.0	252.0	252.0	0.0	252.0
Tot.	1241.8	127.2	1369.0	1356.9	88.1	1445.0	1446.4	1.1	1447.5	1447.5	0.0	1447.5
	Lot I Calf 775			Lot II Calf 771			Lot III Calf 774			Lot IV Calf 763		
1	211.3	4.2	215.5	215.5	0.0	215.5	211.4	4.1	215.5	215.5	0.0	215.5
2	224.0	0.0	224.0	224.0	0.0	224.0	224.0	0.0	224.0	224.0	0.0	224.0
3	180.0	72.0	252.0	252.0	0.0	252.0	252.0	0.0	252.0	252.0	0.0	252.0
4	172.0	50.0	222.0	252.0	0.0	252.0	252.0	0.0	252.0	252.0	0.0	252.0
5	151.2	21.8	173.0	252.0	0.0	252.0	252.0	0.0	252.0	252.0	0.0	252.0
6	140.2	34.3	174.5	252.0	0.0	252.0	252.0	0.0	252.0	252.0	0.0	252.0
Tot.	1078.7	182.6	1261.0	1447.5	0.0	1447.5	1443.4	4.1	1446.5	1447.5	0.0	1447.5
	Lot I Calf 769			Lot II Calf 770			Lot III Calf 765			Lot IV Calf 767		
1	215.0	0.5	215.5	215.5	0.0	215.5	215.5	0.0	215.5	211.3	4.2	215.5
2	224.0	0.0	224.0	224.0	0.0	224.0	216.4	7.6	224.0	224.0	0.0	224.0
3	208.3	43.7	252.0	252.0	0.0	252.0	215.8	36.2	252.0	252.0	0.0	252.0
4	210.8	12.7	223.5	252.0	0.0	252.0	249.6	2.4	252.0	214.6	25.4	240.0
5	229.1	15.4	244.5	252.0	0.0	252.0	250.0	2.0	252.0	252.0	0.0	252.0
6	186.2	36.3	222.5	252.0	0.0	252.0	252.0	0.0	252.0	252.0	0.0	252.0
Tot.	1273.4	108.6	1382.0	1447.5	0.0	1447.5	1399.3	48.2	1447.5	1405.9	29.6	1435.5
	Lot I Calf 764			Lot II Calf 772			Lot III Calf 766			Lot IV Calf 768		
1	215.5	0.0	215.5	210.7	4.8	215.5	215.5	0.0	215.5	215.1	0.4	215.5
2	207.7	16.3	224.0	224.0	0.0	224.0	224.0	0.0	224.0	220.1	3.9	224.0
3	197.8	54.2	252.0	252.0	0.0	252.0	187.2	64.8	252.0	252.0	0.0	252.0
4	193.5	36.5	230.0	252.0	0.0	252.0	235.9	16.1	252.0	252.0	0.0	252.0
5	208.2	22.3	230.5	252.0	0.0	252.0	232.1	19.9	252.0	252.0	0.0	252.0
6	193.0	29.5	222.5	235.3	16.7	252.0	239.3	12.7	252.0	252.0	0.0	252.0
Tot.	1215.7	158.8	1374.5	1426.0	21.5	1447.5	1334.0	113.5	1447.5	1443.2	4.3	1447.5
G.T.	4809.6	572.2	5386.5	5677.9	109.6	5787.5	5623.0	166.9	5790.0	5744.1	33.9	5778.0

TABLE XIII

ECONOMICAL ASPECT OF LOW AND AVERAGE PHOSPHORUS RED CLOVER HAYS FOR WINTERING GROWING CALVES

	Lot I Amount		Lot II Amount	
	Pounds	Dollar	Pounds	Dollars
High-p. hay			1055	$ 7.94
Low-P. hay	896	$ 6.74		
Corn meal	292	4.69	344	5.50
Salt (NaCl)	12	.12	14	.14
Cod liver oil	3	1.80	3.5	2.10
Per animal	1250	$13.25	1416.5	$15.68
Feed cost per 100# gain		$37.85		$15.22
	Lot III		Lot IV	
High-p. hay			1070	$ 8.02
Low-p. hay	1047	$ 7.85		
Corn meal	327	5.23	339	5.42
Salt (NaCl)	14	.14	14	.14
Cod liver oil	3.5	2.10	3.5	2.10
Dicalcium phosphate	14	.42	9	.27
Per animal	1405.5	$15.74	1435.5	$15.95
Feed cost per 100# gain		$17.49		$14.64

Feed prices: Hay @ $15.00 per ton, Corn meal @ $0.90 bu., Salt @ $1.00 per 100#, C.L.O. @ $0.60 per lb. and Dicalcium phosphate @ $3.00 per 100#.

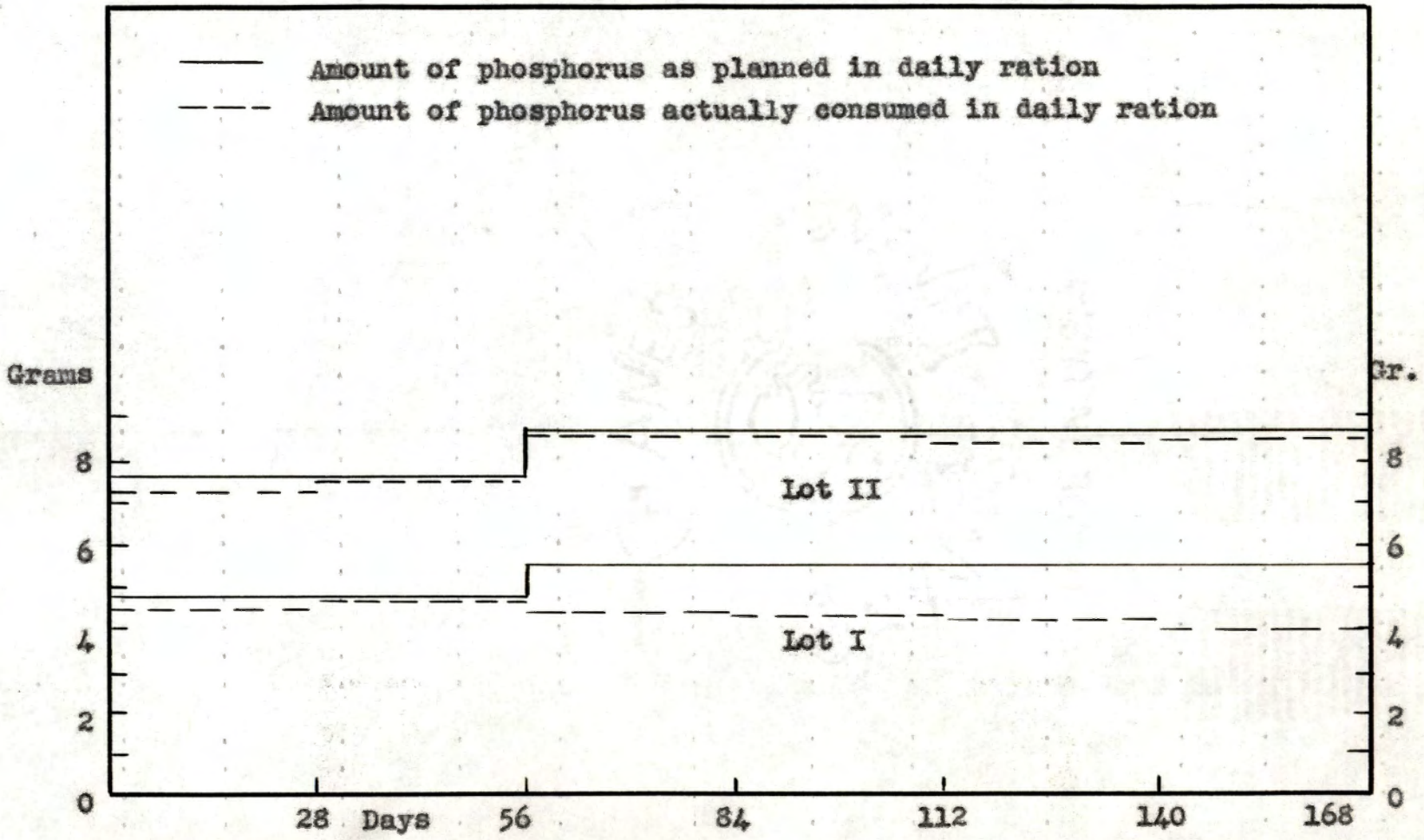


Figure 5. Daily phosphorus intake--as planned and as actually consumed

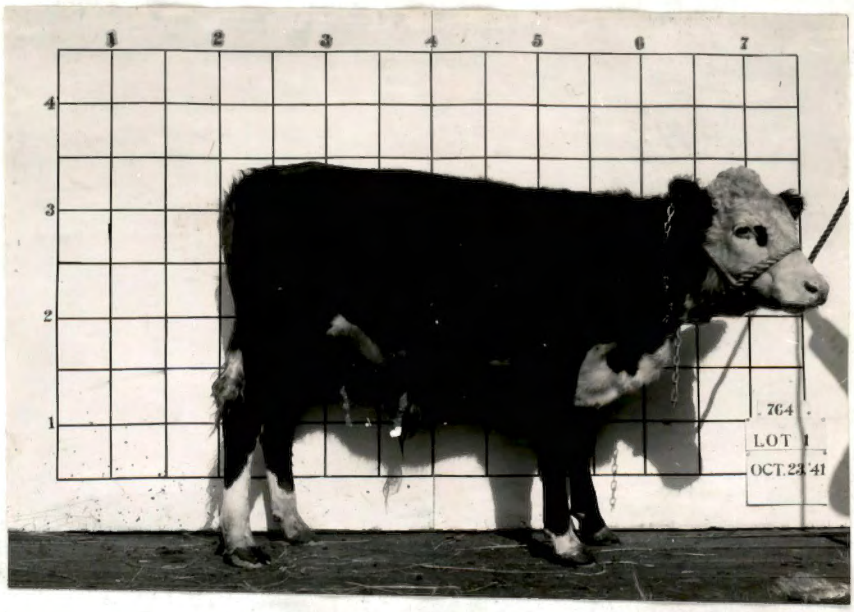


Figure 6a. Calf 764, Lot I, at start of experiment

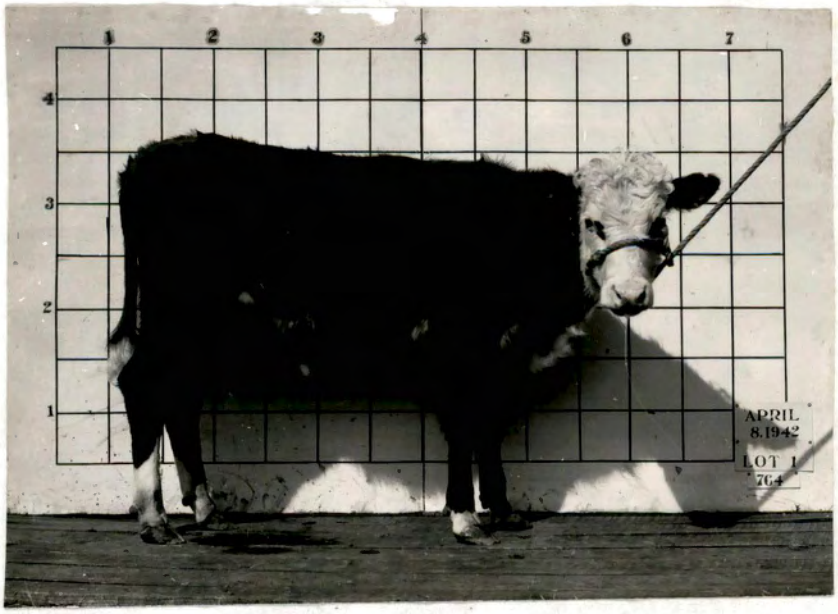


Figure 6b. Calf 764, Lot I, at end of experiment

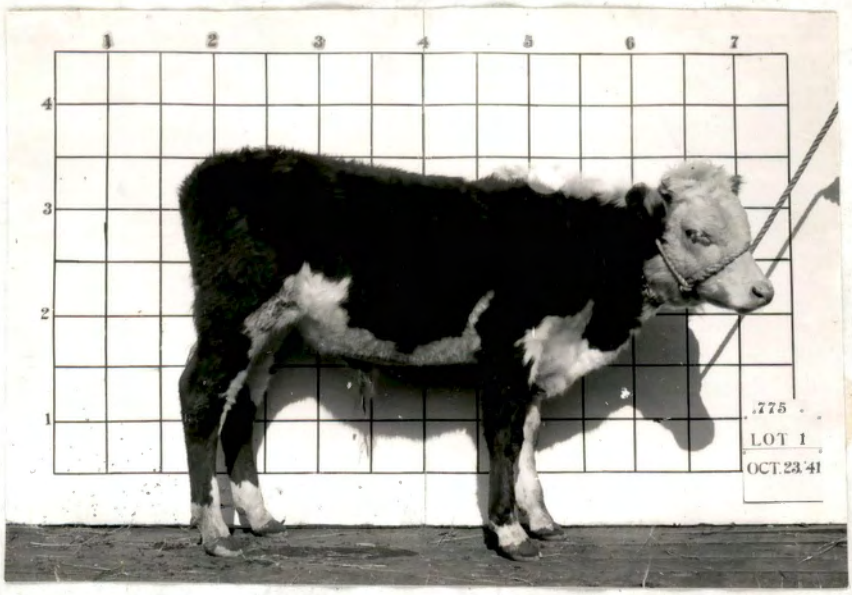


Figure 7a. Calf 775, Lot I, at start of experiment

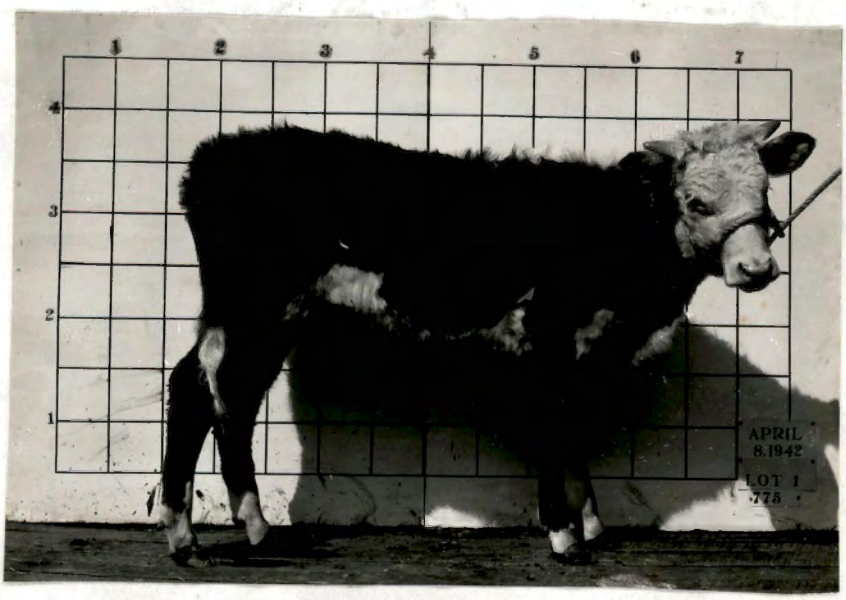


Figure 7b. Calf 775, Lot I, at end of experiment

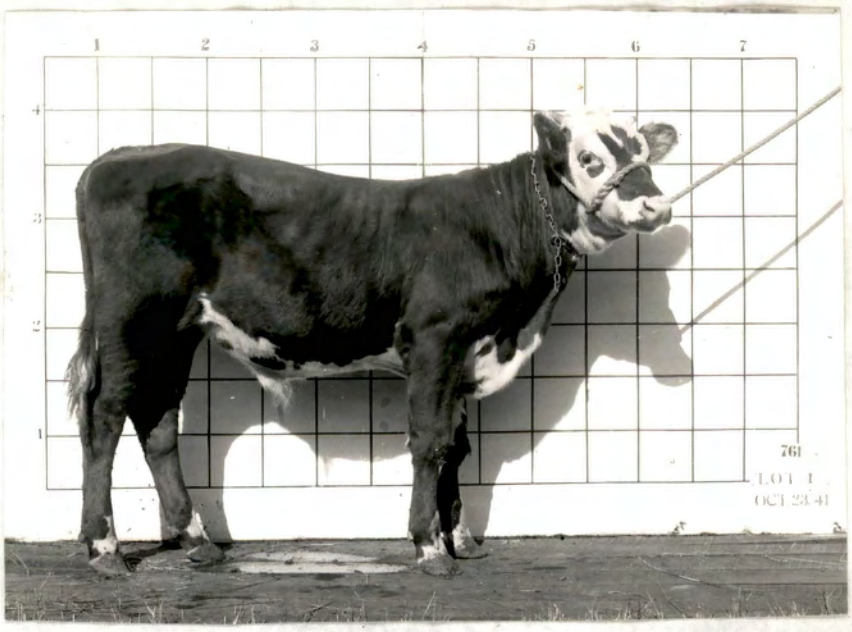


Figure 8a. Calf 761, Lot I, at start of experiment

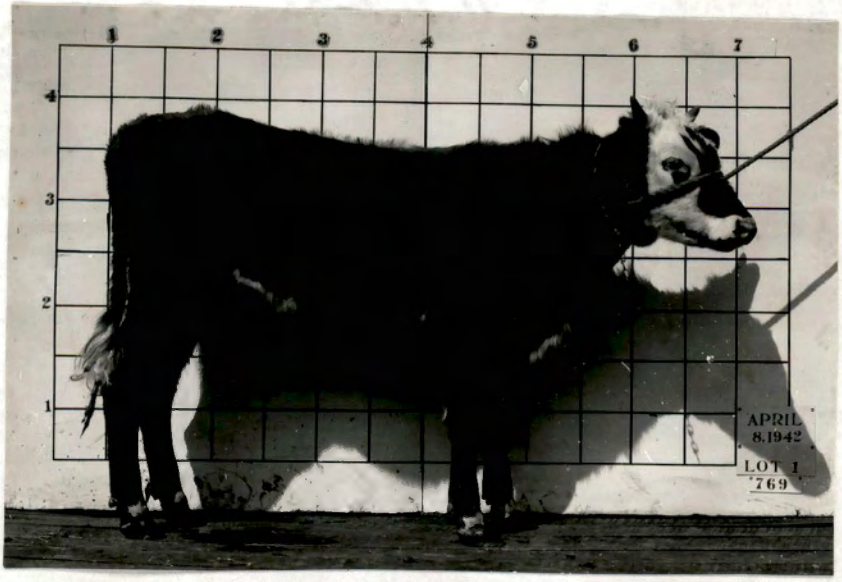


Figure 8b. Calf 761, Lot I, at end of experiment



Figure 9a. Calf 769, Lot I, at start of experiment

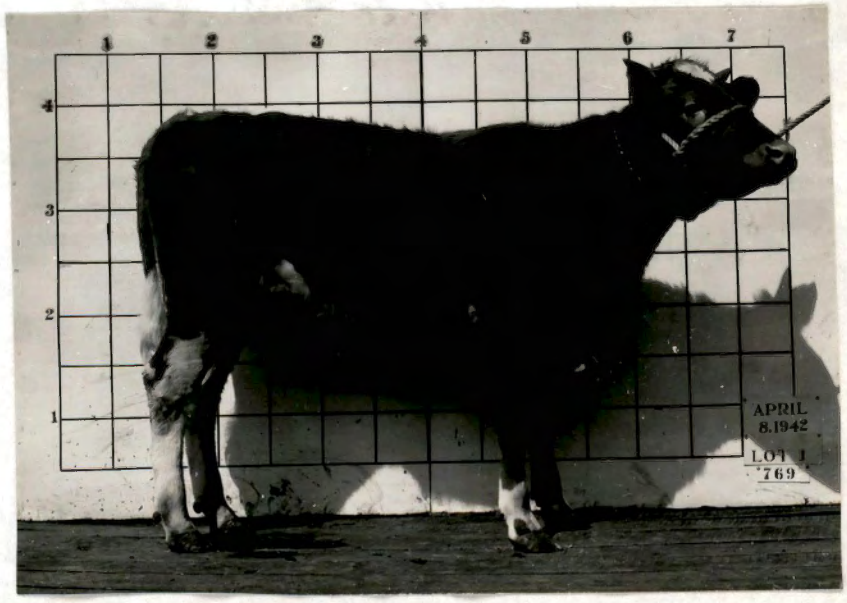


Figure 9b. Calf 769, Lot I, at end of experiment

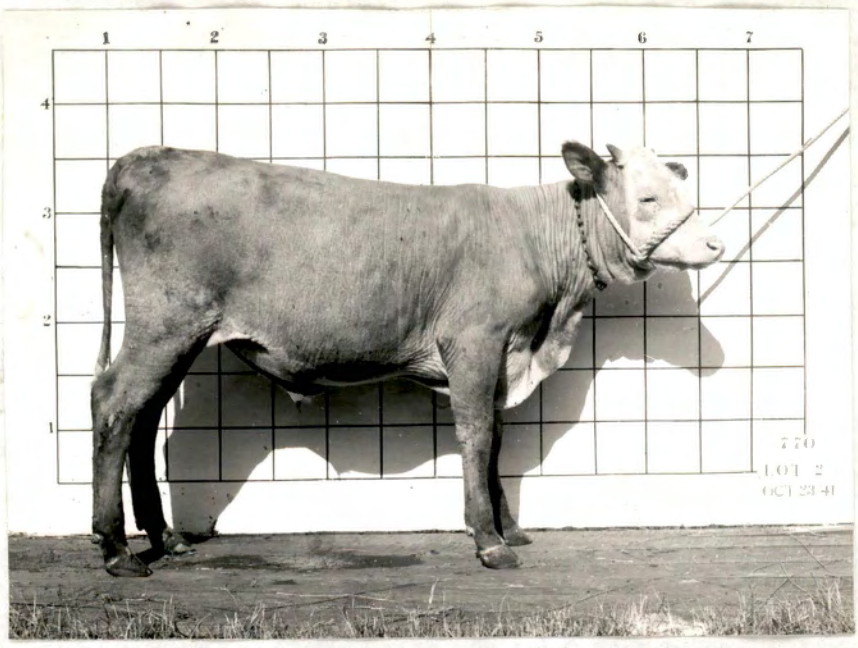


Figure 10a. Calf 770, Lot II, at start of experiment

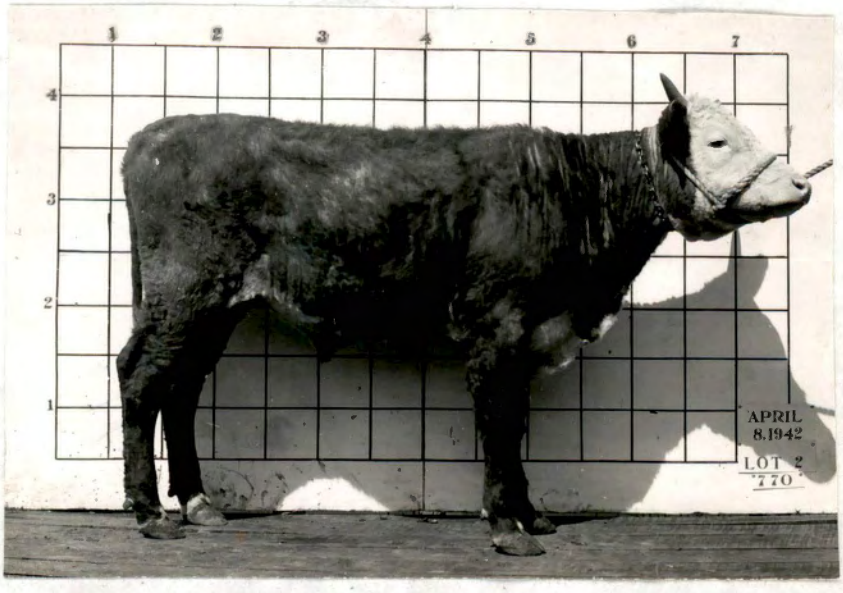


Figure 10b. Calf 770, Lot II, at end of experiment

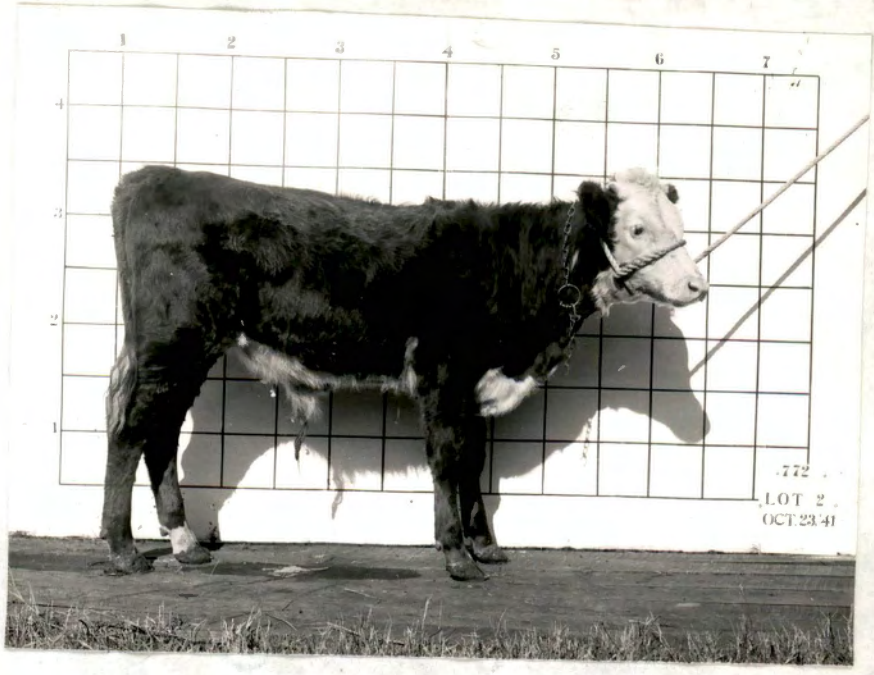


Figure 11a. Calf 772, Lot II, at start of experiment

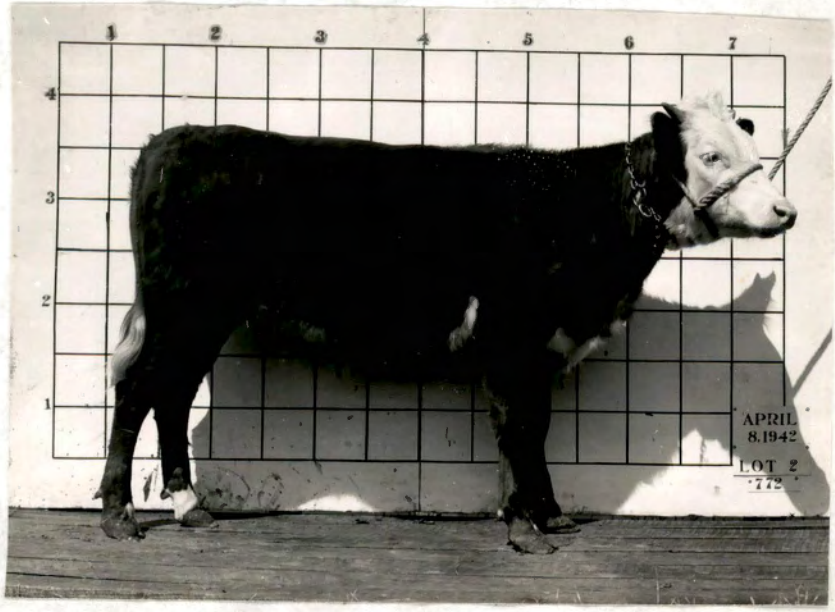


Figure 11b. Calf 772, Lot II, at end of experiment

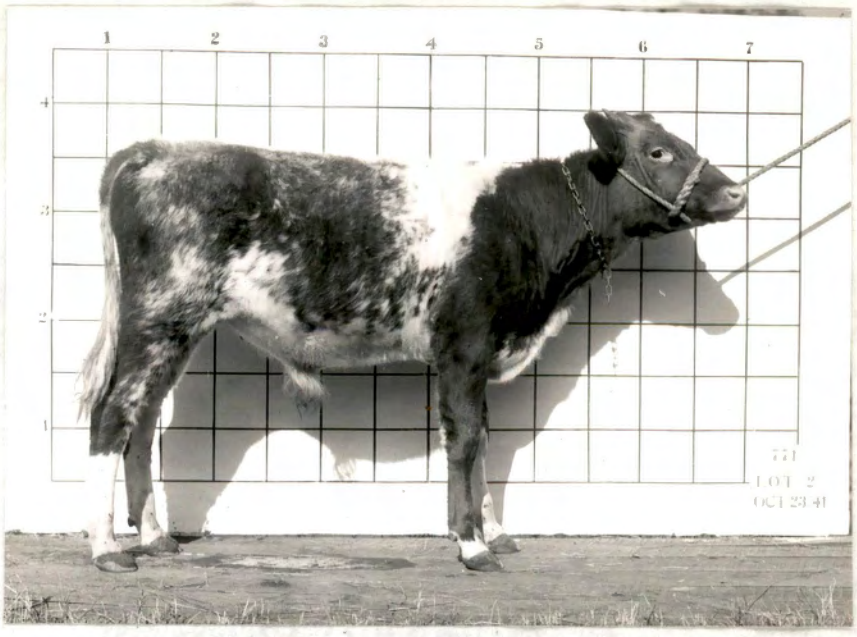


Figure 12a. Calf 771, Lot II, at start of experiment

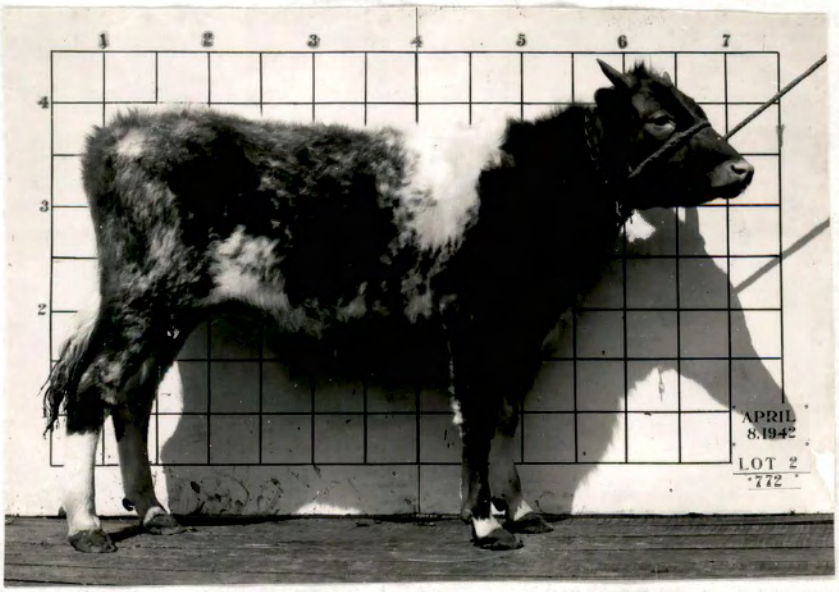


Figure 12b. Calf 771, Lot II, at end of experiment

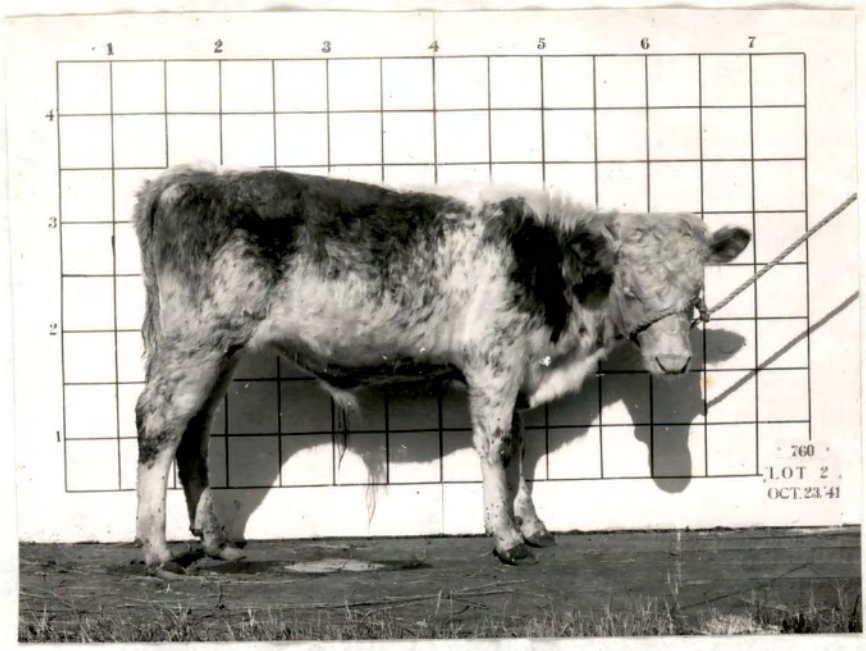


Figure 13 a. Calf 760, Lot II, at start of experiment

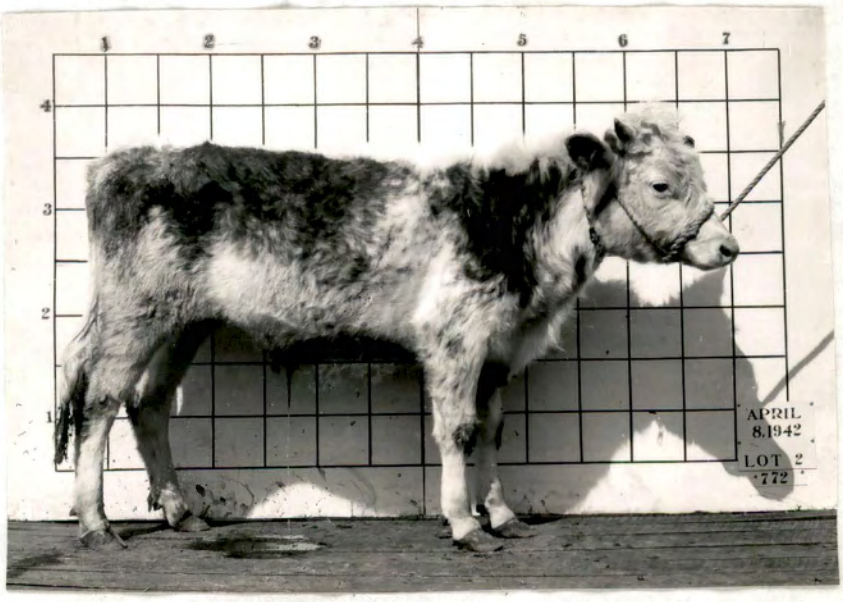


Figure 13b. Calf 760, Lot II, at end of experiment

The Effects of Adding a Phosphorus Supplement to a Clover Hay of low Phosphorus Content.

The ration for Lot III was set up to compare the effects of adding a liberal phosphorus supplement to the low phosphorus ration of Lot I. Based on data published by Mitchell and McClure (17) the phosphorus content of Ration I was below the minimum requirements for normal growth for 400 pound calves while the phosphorus content of Ration III was considered adequate for calves of this age and weight. It should be kept in mind that the rations for Lots I and III (Table VII) differed only in that dicalcium phosphate was added to Ration I.

A comparison of results obtained from the two rations will be considered in the next few pages.

Weights and Body Measurements.

The calves of Lot III were treated in all respects as previously explained for Lots I and II. The data relating to gains in weight and body measurements, blood analysis, and pictures and observations were obtained at the same time and in like manner for all lots of calves.

Lot III made greater gain in weight as is shown in Table VIII, and is shown graphically in Figure 14. During the first half of the experiment the gains in weight made by the two lots were 17 and 30 pounds

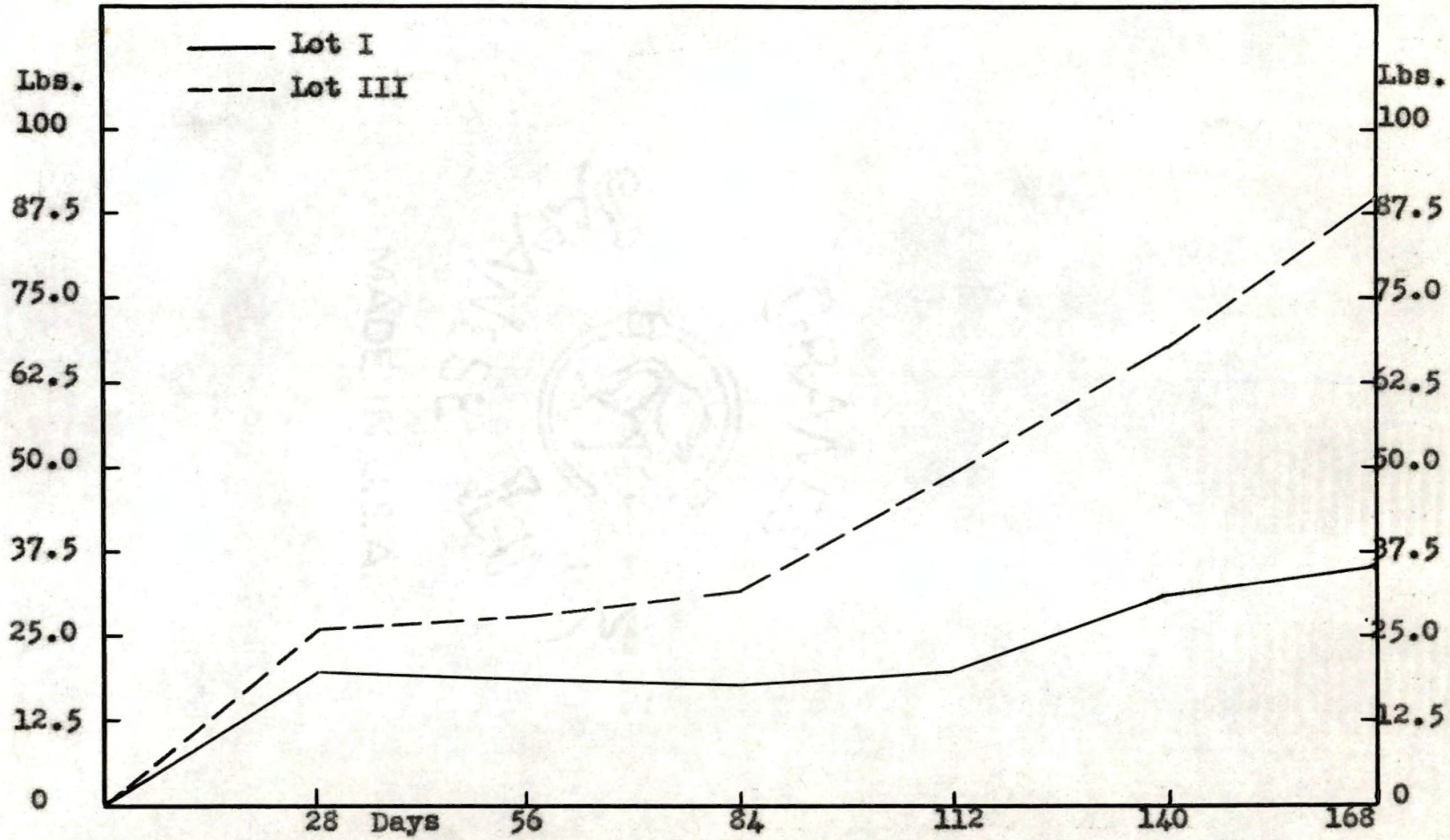


Figure 14. A comparison of gains in weight of Lots I and III

respectively for Lots I and III, as compared with this for the last half of the experiment, Lot I only gained 19 pounds while Lot III gained 59 pounds in the same period of time.

Gains in heart girth and height at withers for Lots I and III are shown in Table IX and X respectively. Lot III consistently made greater gains in both these measurements. A comparison of gains of the two lots is shown in Figure 15 for heart girth and in Figure 16 for height at withers.

The gain in weight by Lot III was not as great as that made by Lot II which was being fed the average phosphorus hay without a phosphorus supplement. A comparison of gains made by Lot II, receiving only a minimum amount of phosphorus (based on data published by Mitchell and McClure), and Lot III receiving an adequate amount of phosphorus for all functions of normal growth, indicates that there may be another factor or factors than phosphorus that is limiting growth. As mentioned previously, this may be due to the variations of the nutritive ratios or total amount of protein fed in the different rations.

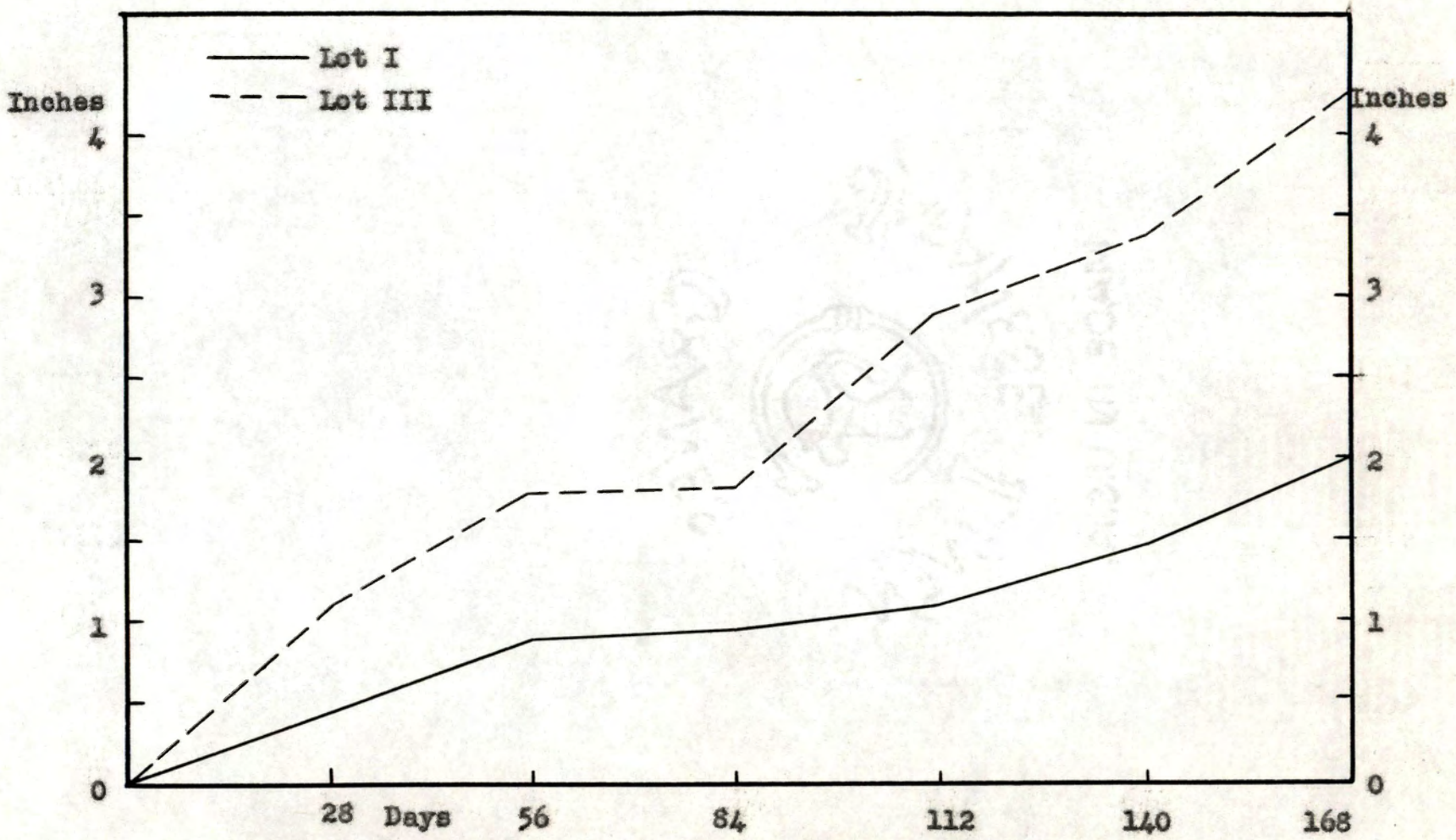


Figure 15. A comparison of gains in heart girth by Lots I and III

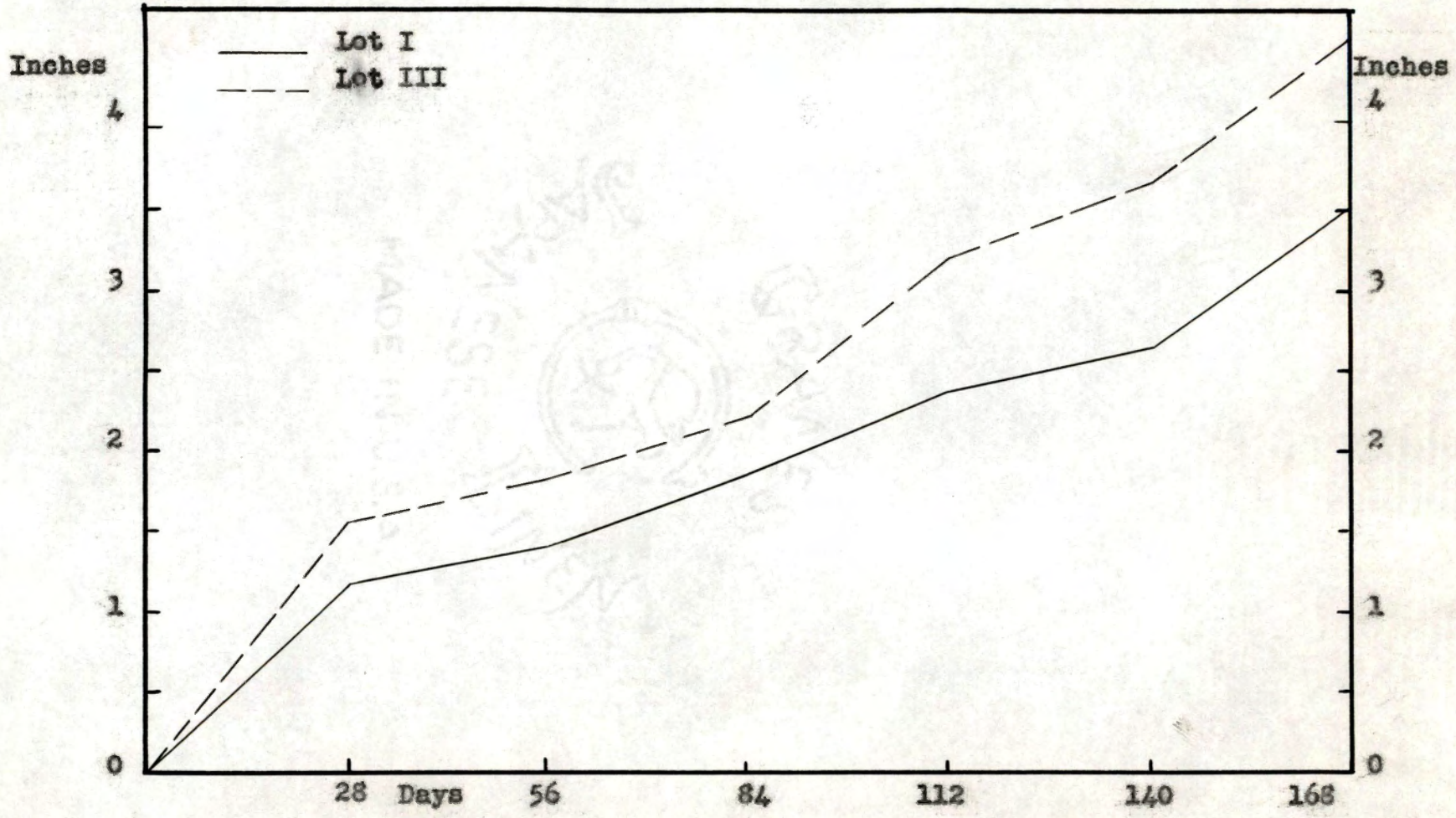


Figure 16. A comparison of gains in height at withers by Lots I and III

Blood Analysis.

The blood phosphorus content in milligrams per 100 milliliters of whole blood is shown in Table XI for each calf at the beginning of the experiment and at the end of each period. The blood phosphorus content of both lots were below what is considered normal at the beginning of the experiment (based on S. R. Johnson's data). This was probably due to the preliminary ration being low in phosphorus.

It will be noted in Figure 17 that the blood phosphorus content for Lot I remained considerably below the minimum range except for the value for the end of the second period which was just within the minimum range. The blood phosphorus content of Lot III increased in the first period and remained close to the average for the remainder of the experiment.

Economical Aspect of Low and Average Phosphorus Red Clover Hay for Wintering Growing Calves.

It is shown in Table XII that the addition of dicalcium phosphate to the rations containing the low phosphorus hay raised the feed cost $2.49 on a per animal basis for wintering the calves over a 168 day period. When the calculation is made on a 100 pounds gain basis the cost is lowered $20.36 by the addition of a phosphorus supplement. A comparison of the phosphorus planned in the ration and actually consumed by Lots I and III is shown in Figure 18.

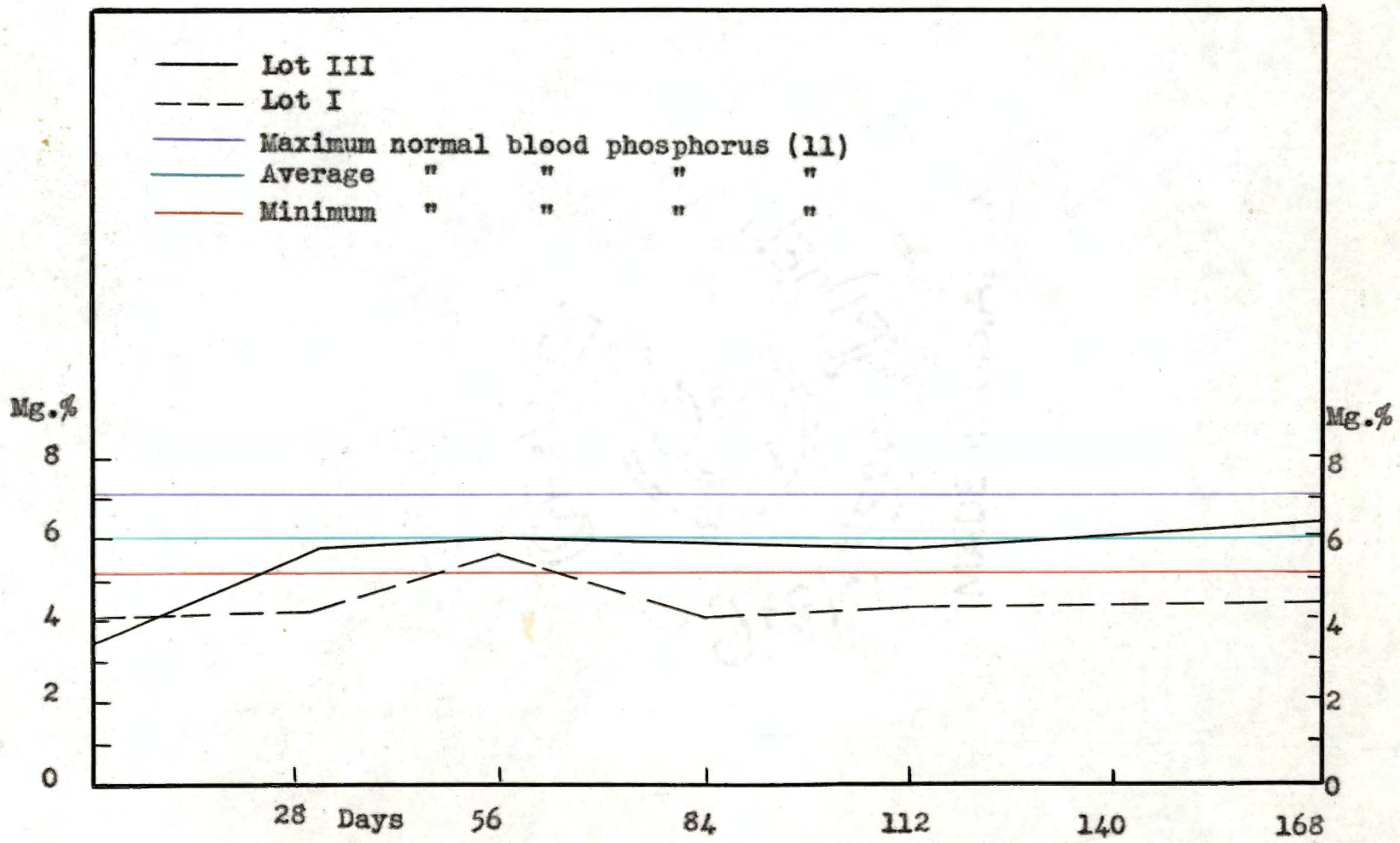


Figure 17. Blood phosphorus for Lots I and III - Mg. per 100 Ml. W. B.

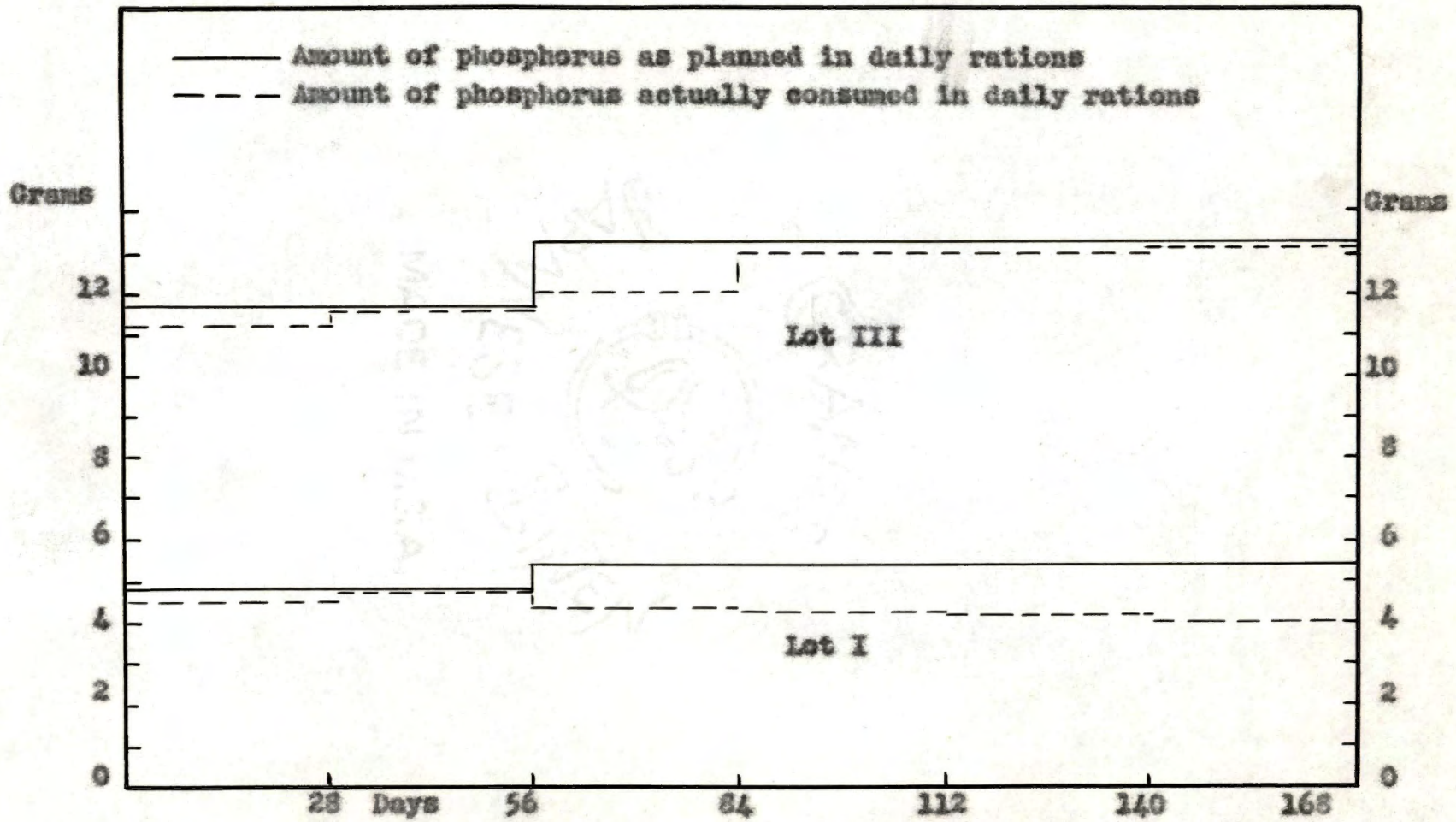


Figure 18. Daily phosphorus intake--as planned and as actually consumed

Pictures and Observations.

Pictures of the calves in Lot I are shown in Figures 7 to 10 inclusive and for Lot III in Figures 19 to 23 inclusive. The calves in Lot I consumed most of the feed given for the first two periods, after this time they failed to consume all the feed planned in the ration. Figure 18 shows that beginning at the end of the second period the calves in Lot I consumed progressively less feed with each period while feed consumption of Lot III was near the amount planned in the ration.

Calves in both lots continued to eat wood shavings, chew the wood in the stalls and generally show a depraved appetite for the entire experimental period. There were not any signs of swelling of joints, lameness or other indications of malnutrition in either lots.



Figure 19a. Lot III, Calf 765, at start of experiment

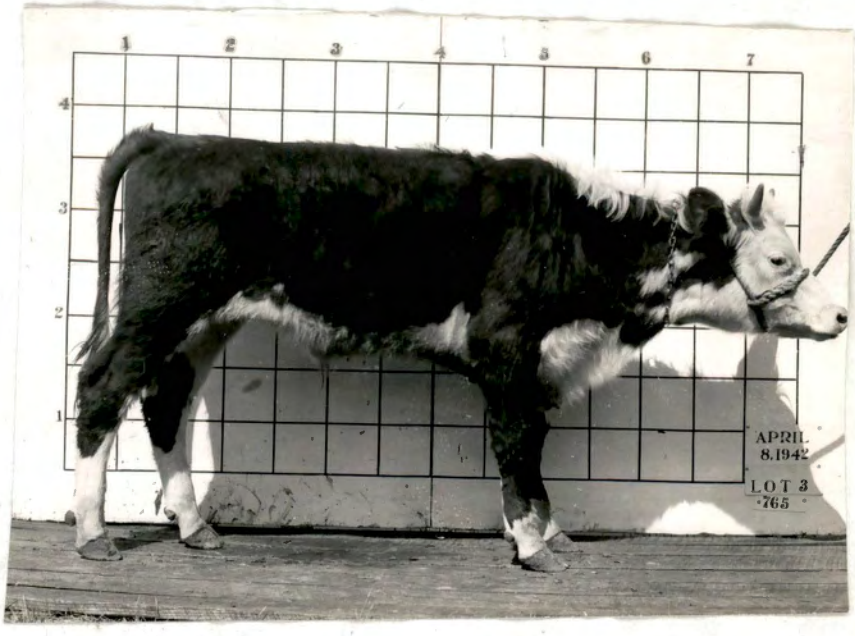


Figure 19b. Lot III, Calf 765, at end of experiment



Figure 20a. Lot III, Calf 766, at start of experiment

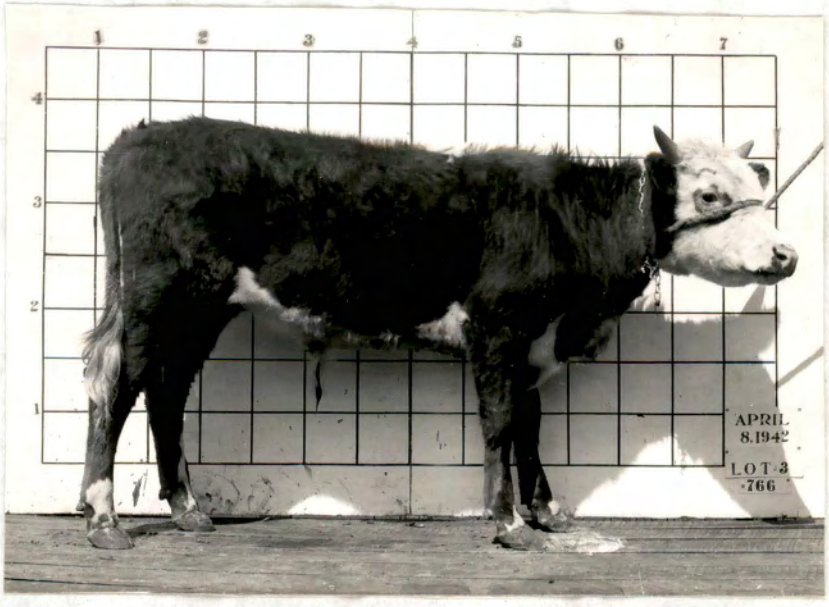


Figure 20b. Lot III, Calf 766, at end of experiment

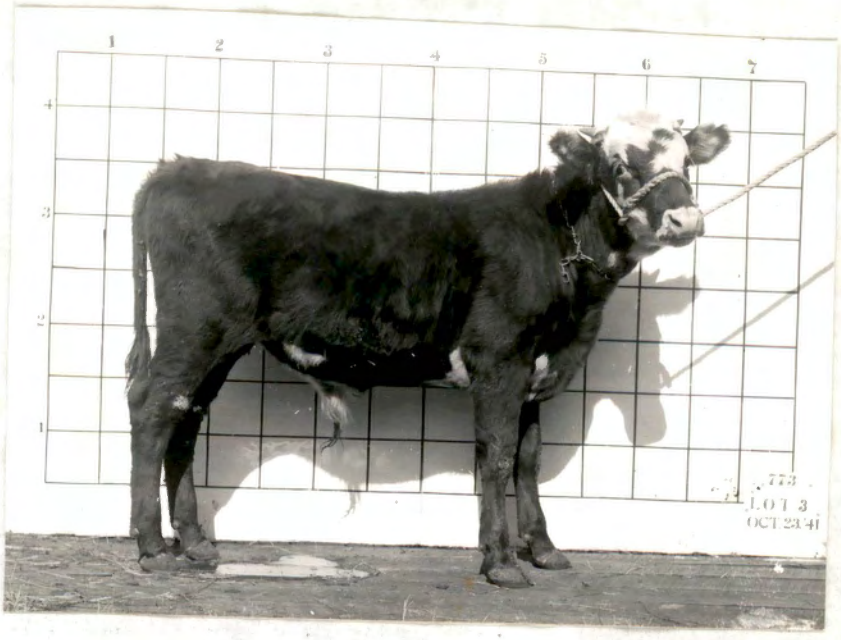


Figure 21a. Lot III, Calf 773, at start of experiment

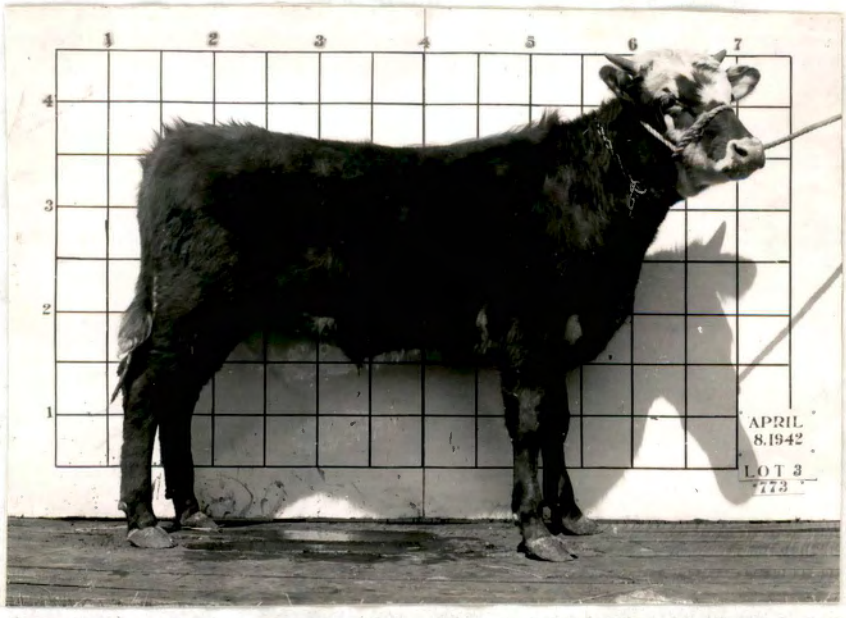


Figure 21b. Lot III, Calf 773, at end of experiment

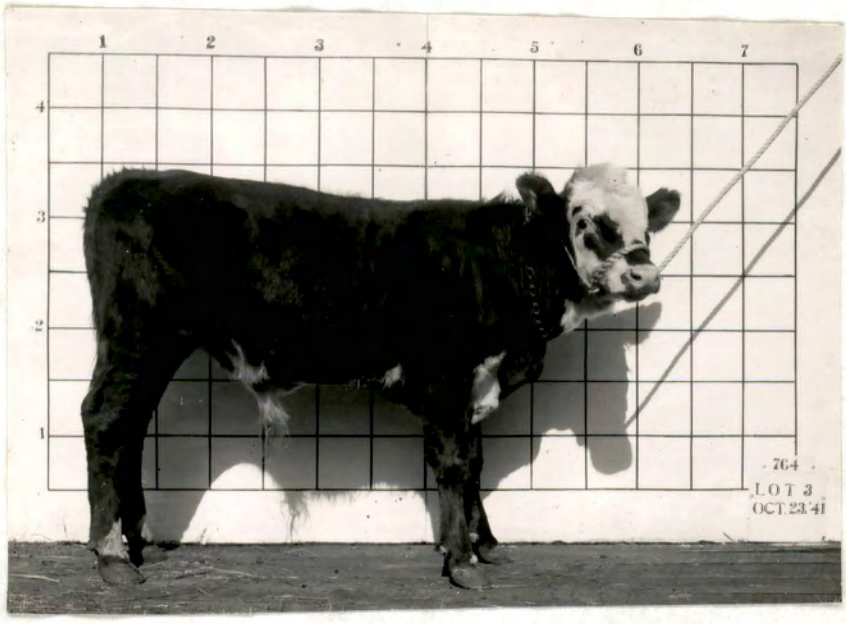


Figure 22a. Lot III, Calf 774, at start of experiment

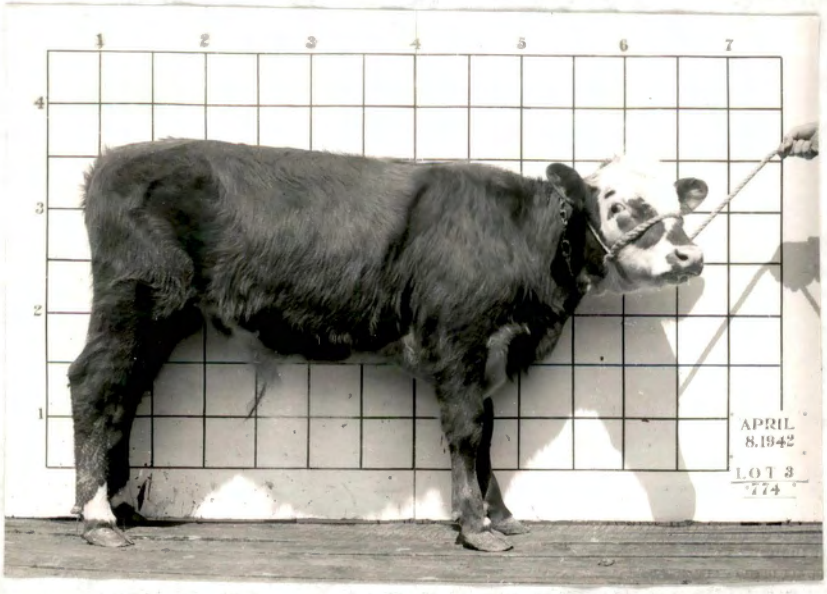


Figure 22b. Lot III, Calf 774, at end of experiment

Effect of Adding a Phosphorus Supplement to a Clover Hay of Average Phosphorus Content

The ration for Lot IV was set-up to compare the effects of adding a liberal phosphorus supplement to the ration fed Lot II. Based on data published by Mitchell and McClure (17) the phosphorus content of Ration II was near the minimum requirement for normal growth for 300 pound calves while the phosphorus content of Ration IV was considered adequate for normal body functions for calves of this age and weight. It should be kept in mind that the rations for Lots II and IV differ only in that dicalcium phosphate was added to Ration 4.

A comparison of results obtained from the two Rations will be considered in the next few pages.

Weights and Body Measurements.

As has been explained previously, the procedure for obtaining the data was similiar in all respects for the various lots of calves.

The addition of a phosphorus supplement to the ration containing the high phosphorus hay did not materially increase the average weight of the calves in Lot IV. A comparison of the gains in weight of the two lots is shown graphically in Figure 24. Both Lots II and IV made greater gains in weight than did Lot III which was receiving an adequate amount of phosphorus. This vari-

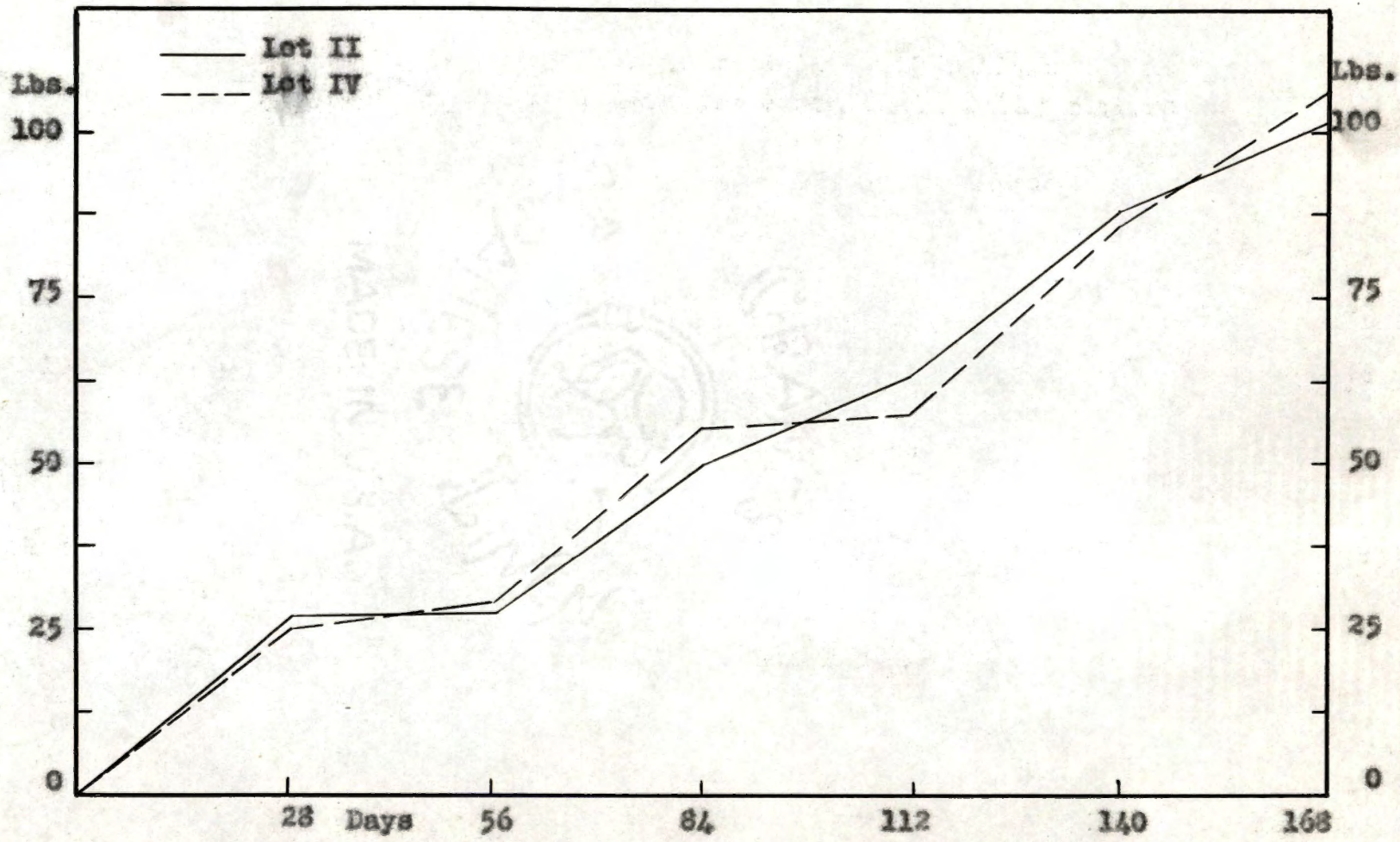


Figure 24. A comparison of gains in weight by Lots II and IV

ation may be accounted for in part, in that the nutritive ratio and total protein of Rations II and IV were more favorable than that for Ration III.

Gains in heart girth and height at withers for Lots II and IV are shown in Table IX and X respectively. A comparison of gains made in height and heart girth is shown graphically in Figures 24 and 25 respectively.

The addition of a phosphorus supplement to the ration containing the average phosphorus hay appeared to have very little influence on the total gain in weight, but caused an increase in height and heart girth.

Blood Analysis

The blood phosphorus content in milligrams per 100 milliliters of whole blood is shown in Table XI for each calf at the beginning of the experiment and at the end of each period. The blood phosphorus content of both lots at the beginning of the experiment were below what is considered normal for calves of this age. This initial low blood phosphorus content was probably due to the preliminary ration being low in phosphorus.

As is shown in Figure 26, the blood phosphorus content of Lot II remained almost consistently below the average, while that of Lot IV increased to above the average for most of the remainder of the experiment.

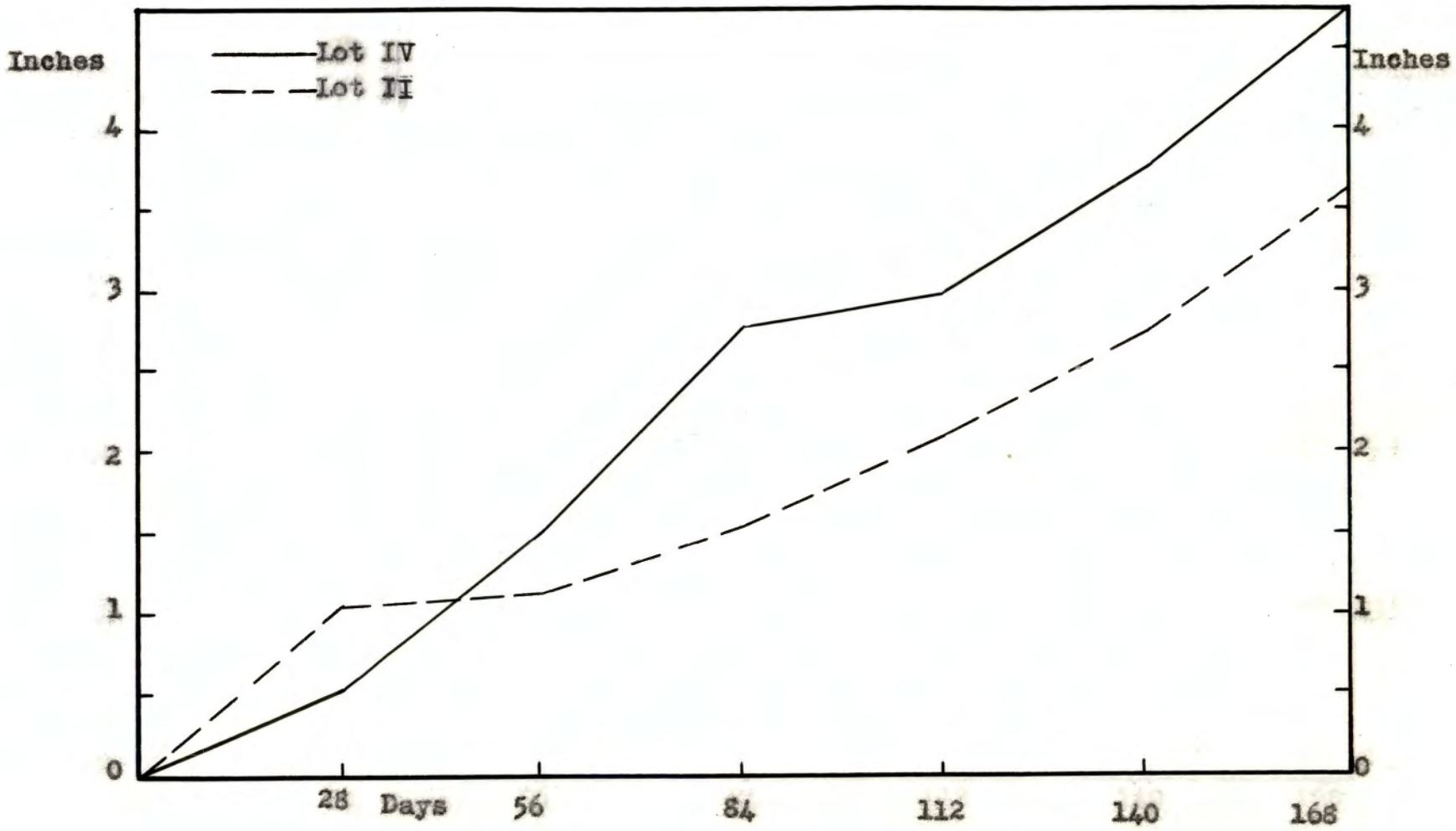


Figure 24. A comparison of gains in heart girth by Lots II and IV

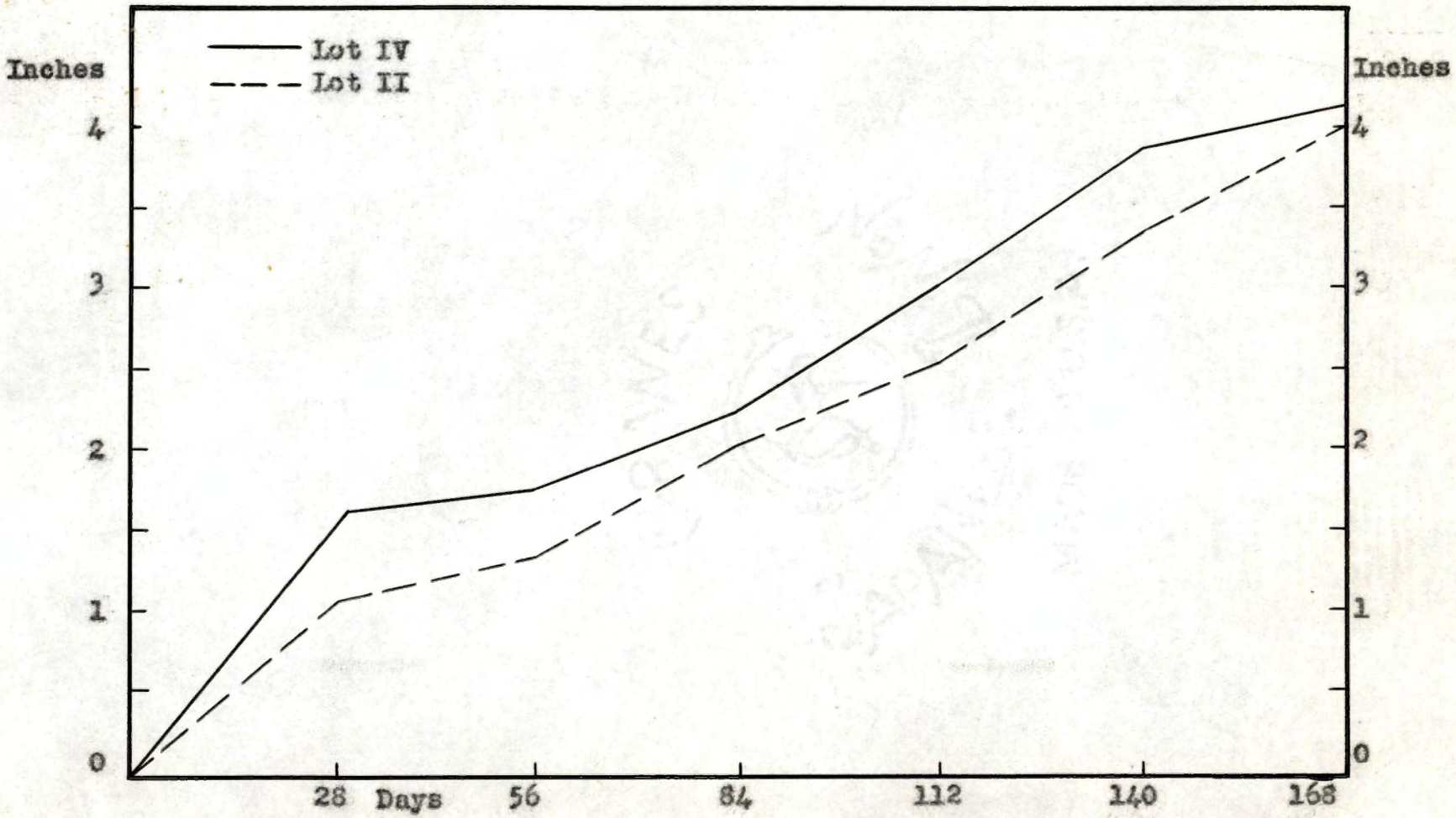


Figure 25. A comparison of gains in height at withers of Lots II and IV

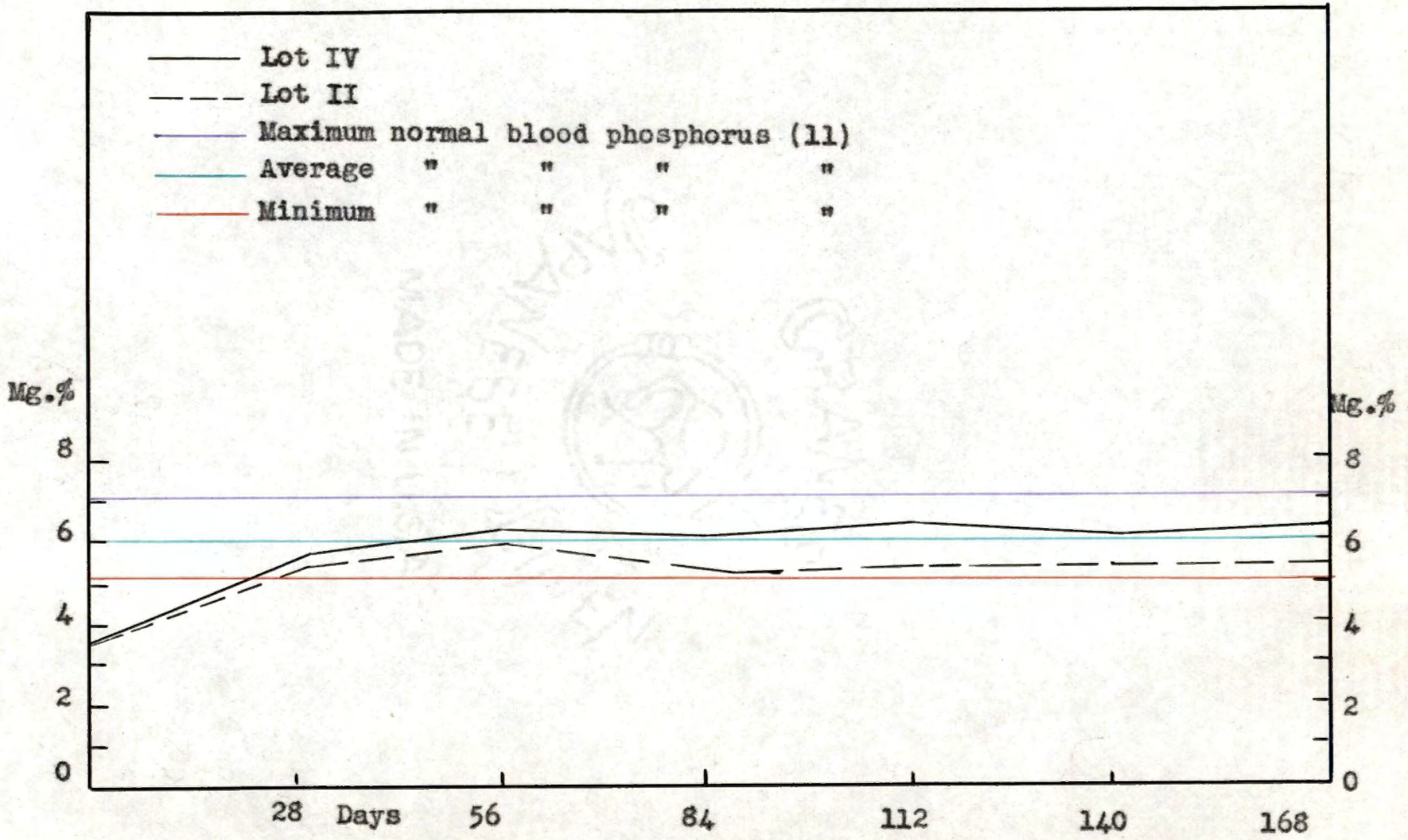


Figure 26. Blood phosphorus for Lots II and IV. Mg. Per 100 Ml. W. B.

Economical Aspect of Adding a Liberal Phosphorus Supplement to a ration of which the Roughage is made-up of average Phosphorus Red Clover Hay.

It is shown in Table XIII that the addition of dicalcium phosphate to the rations containing the average phosphorus hay increased the total feed cost of wintering the calves over a 168 day period only $0.27 and decreased the cost per 100 pounds gain only $0.58.

The amount of feed fed, refused and consumed by the individual calves is given in Table XII. There was little difference in the consistency of feed consumption of the two lots of calves.

A comparison of the phosphorus planned in the ration and actually consumed by Lots II and IV is shown in Figure 27.

Pictures and Observations.

Pictures of the calves in Lot II are shown in Figures 10 to 13 inclusive and for Lot IV in Figures 28 to 31 inclusive. The calves in both lots were fairly consistent in consuming all feed given.

Daily phosphorus intake, as planned and as actually consumed, is shown in Figure 27.

Calves in both lots continued to eat wood shavings, chew the wood of stalls and generally show a depraved appetite for the entire experimental period. There was not any signs of swelling of joints, lameness or other indications of malnutrition in either of the two lots.

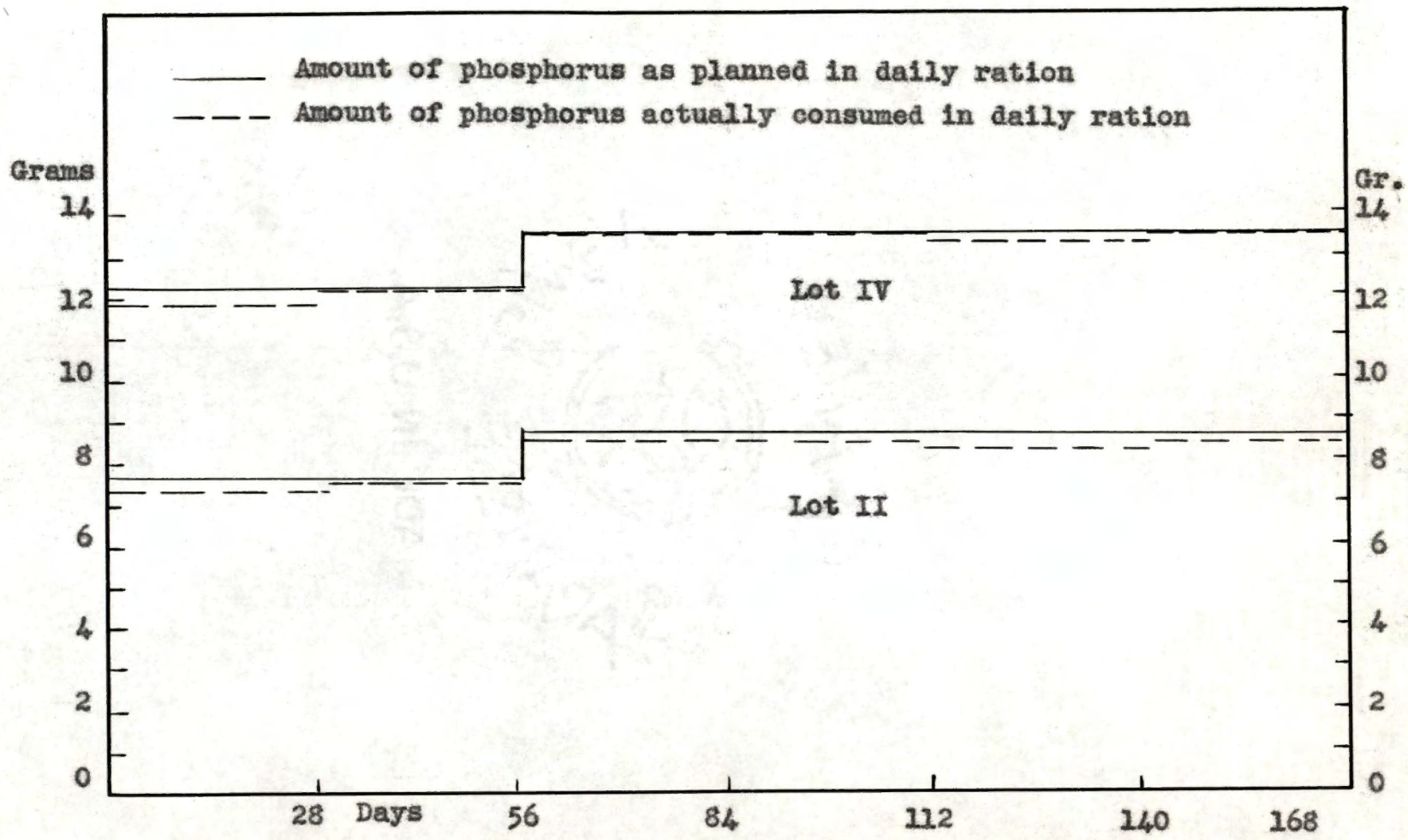


Figure 27. Daily phosphorus intake--as planned and as actually consumed

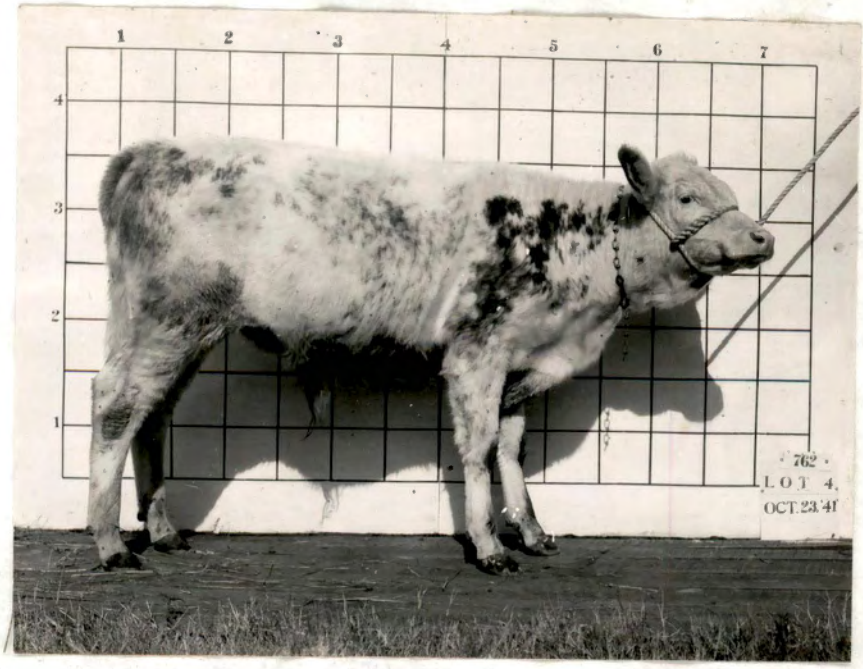


Figure 28a. Lot IV, Calf 762, at start of experiment

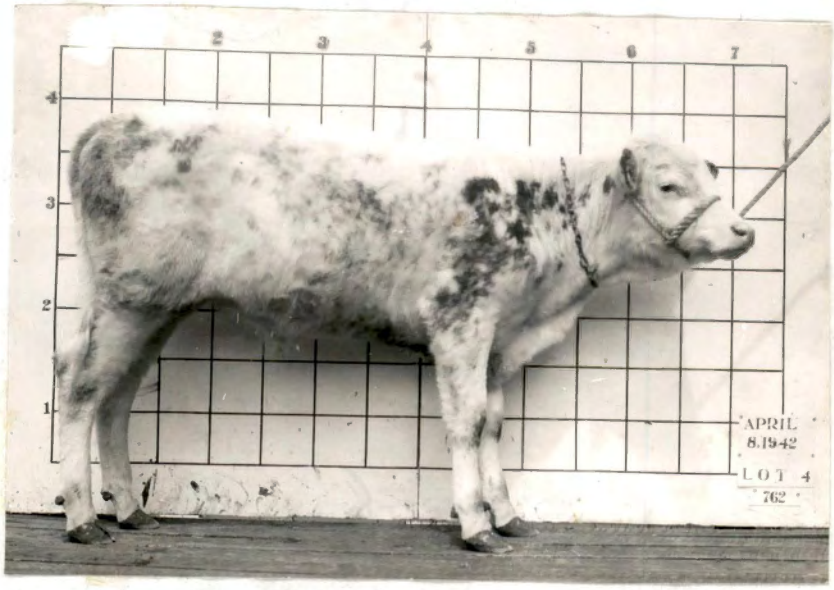


Figure 28b. Lot IV, Calf 762, at end of experiment

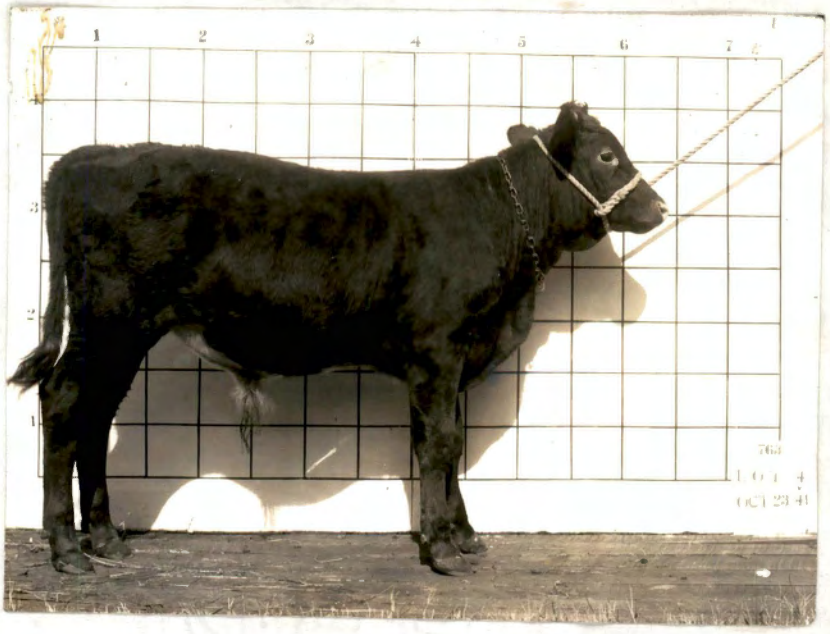


Figure 29a. Lot IV, Calf 763, at start of experiment



Figure 29b. Lot IV, Calf 763, at end of experiment

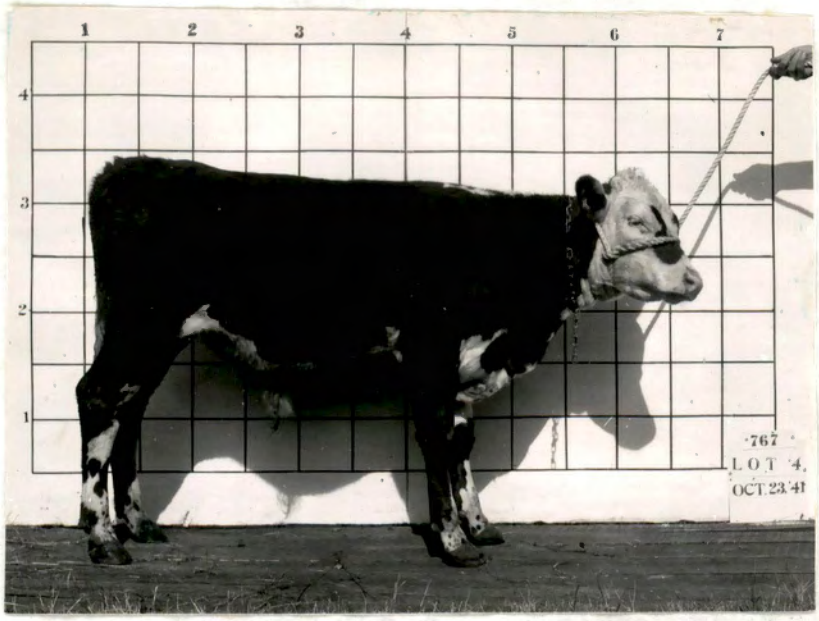


Figure 30a. Lot IV, Calf 767, at start of experiment

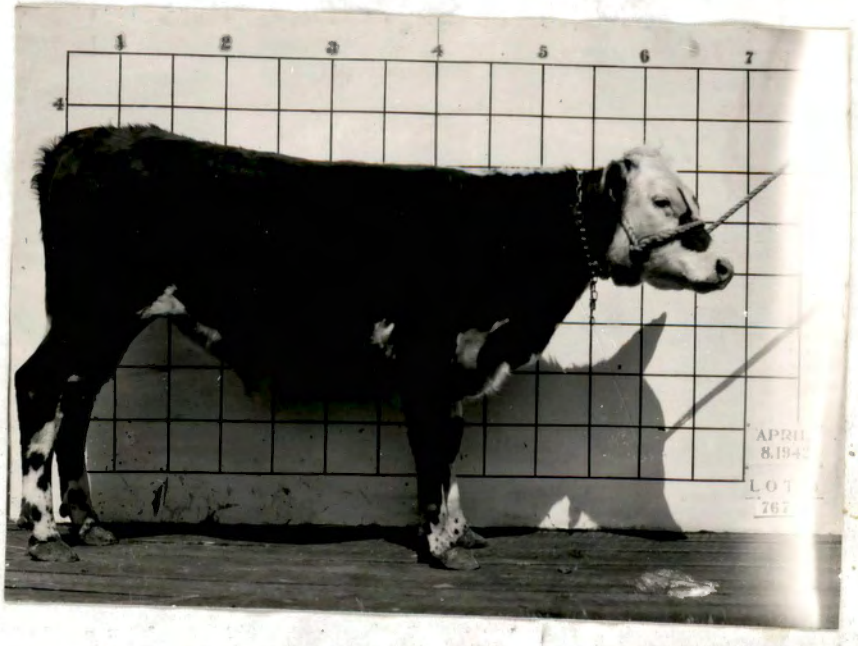


Figure 30b. Lot IV, Calf 767, at end of experiment

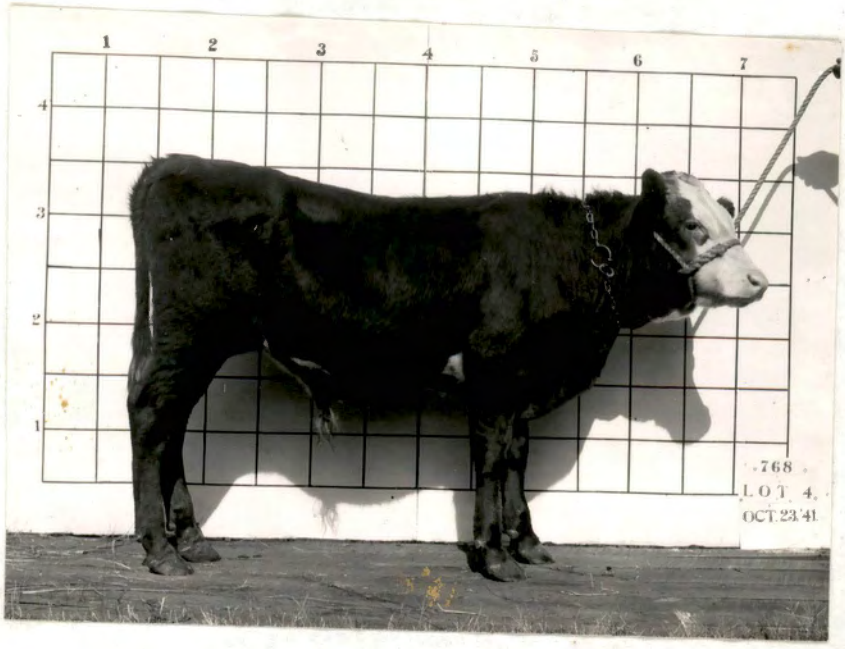


Figure 31a. Lot IV, Calf 768, at start of experiment

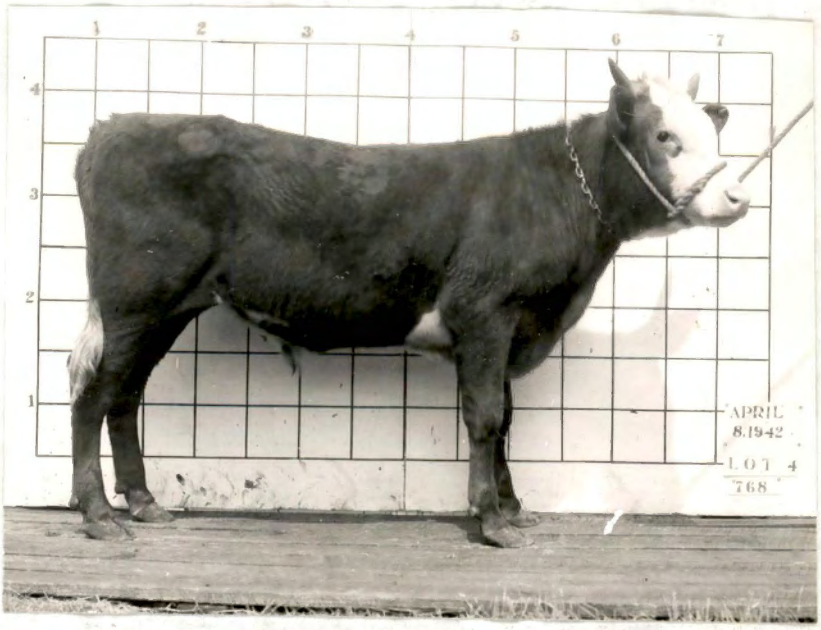


Figure 32b. Lot IV, Calf 768, at end of experiment

SUMMARY

The objectives of this experiment were to (A) compare the feeding value of a red clover hay of a good average phosphorus content with a red clover of low phosphorus content, as the roughage in a wintering ration for growing calves, and (B) to compare the effects of adding a liberal phosphorus supplement to rations fed for Objective "A".

The calves of Lot I were fed a ration containing red clover hay of low phosphorus content. This ration contained about 5 grams of phosphorus per calf daily. Based on data published by Mitchell and McClure, this ration was below the minimum requirements for normal growth when fed to calves of this age and weight. The calves gained only an average of 36 pounds for the 168 days period, developed poor appetites, and the blood phosphorus content remained below the minimum range for the entire experimental period.

The calves of Lot II were treated in all respects as those in Lot I except the roughage content was composed of red clover hay of an average phosphorus content. This ration contained the minimum requirements (Mitchell and McClure) of 8 grams of phosphorus for normal growth. Feed consumption by the calves of Lot II was fairly consistent over the entire period. These calves gained an average of 102 pounds over the 168-day period, consumed nearly all

feed given, and the blood phosphorus content remained below the normal average for most of the period but well within the normal range. Average gain in heart girth for Lot II was 3.6 inches for the 168 day period while Lot I only gained 2.0 inches during the same time. Skeletal growth, as the measured by height at withers favored Lot II slightly in that Lot I gained 3.7 inches and Lot II 4.0 inches.

The calves of Lot III were used to compare the effect of adding a liberal phosphorus supplement to the ration containing the low phosphorus hay. This ration contained about 12.5 grams of phosphorus. This amount of phosphorus is considered by Mitchell and McClure to be adequate for normal growth when fed to 400 pound growing calves. The addition of the phosphorus supplement in this ration on Lot III improved it materially. The calves of this lot gained an average of 90 pounds as compared with 36 for the calves without the supplement. The gain in heart girth was 2.0 and 4.2 inches respectively for Lots I and III while the gain in height at withers was 3.7 and 4.6 inches respectively for Lots I and III. Lot III consumed practically all feed planned in the ration while Lot I was very inconsistent in feed consumption and failed to consume all feed planned in thr ration. The blood phosphorus content of the animals of Lot III became normal soon after the experiment was begun and remained near average for most of the

experimental period while the blood phosphorus content for the calves of Lot I remained considerably below the minimum range for the entire experimental period.

The calves of Lot IV were used to compare the effect of adding a phosphorus supplement to the ration containing the regular phosphorus hay. This ration contains approximately 12.5 grams of phosphorus. The addition of this supplement did not give any marked improvement in the performance of the calves of Lot IV. The calves receiving the supplement gained an average of 109 pounds as compared to 102 pounds for the calves not receiving the supplement. Feed consumption by the two lots was similar and both lots were fairly consistent in consuming all feed planned in the rations. The gains in heart girth were 3.6 and 4.7 inches, in height at withers were 4.0 and 4.1 inches, respectively for Lots II and IV. The blood phosphorus content for the animals of Lot IV increased to above average soon after the beginning of the experiment and remained above average for the remainder of the experimental period while the blood phosphorus content of Lot II remained below average but well within the normal range.

CONCLUSIONS

The data obtained under the conditions of this experiment indicate that:

(1) Red clover hay of a low (0.10 percent) phosphorus content is not satisfactory as the roughage in the wintering ration used for growing calves.

(2) Red clover hay of an average phosphorus content (0.20 percent) is satisfactory as the roughage in a wintering ration for growing calves and considerably more desirable than red clover with a low phosphorus content.

(3) The addition of a liberal phosphorus supplement to the ration containing the low phosphorus hay gave very beneficial results in that it: (a) increased the gain in weight from 36 to 102 pounds, (b) increased growth in heart girth from 2.0 to 4.2 inches, (c) increased the gain in height at withers from 3.7 to 4.6 inches, (d) increased the blood phosphorus content from below normal to average and (e) lowered the feed cost per 100 pounds gain from $37.86 to $17.49.

(4) The addition of a liberal phosphorus supplement to the ration containing the red clover hay of average phosphorus content produced, on the average, practically no increase in rate of growth but increased somewhat the level of the blood phosphorus content.

(5) A large percentage of the red clover hay produced in certain sections of Tennessee is too low in phosphorus content to give desirable growth when fed without a phosphorus supplement to growing calves.

(6) Eight grams of phosphorus as supplied in the wintering ration chiefly by red clover hay of average phosphorus content appear to be adequate for good growth, although, Mitchell and McClure recommends 12 grams daily as the daily adequate amount of phosphorus to meet the needs of 400 pounds growing calves. The calves of Lot II, receiving only approximately 8 grams of phosphorus daily, gained 102 pounds while the calves of Lot IV, receiving approximately 12.5 grams of phosphorus daily, gained only 109 pounds.

(7) The difference of gain in weight of Lot III as contrasted with Lots II and IV was not sufficient to warrant believing that the wide nutritive ratio and small amount of protein were limiting factors, as Lot III gained 90 pounds in weight compared with 102 and 109 pounds respectively for Lots II and IV.

(8) The results obtained in this experiment are of considerable value to the livestock producer. Although much desirable information was obtained, the data obtained indicate a need for further work.

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