

GROWTH AND DEVELOPMENT OF JERSEY HEIFERS FED DIFFERENT
LEVELS OF PRAIRIE HAY AS THE SOLE ROUGHAGE

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LEVELS OF PRAIRIE HAY AS THE SOLE ROUGHAGE

By

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INTRODUCTION

This study is primarily concerned with the growth and development of Jersey heifers fed limited prairie hay rations. Prairie hay is one of the principal hay crops for dairy cattle in Oklahoma, and is fed in large amounts by dairymen in the state. It is fed very extensively in certain sections where soil and climatic conditions are unfavorable for the production of the legume hay crops.

During periods of drouth when supplies of prairie hay are small and of poor quality, there is a possibility that the feeding of limited amounts of this low quality hay may result in subnormal growth and development of young dairy cattle.

Results discussed in this study show the effects produced on the growth and development of Jersey heifers resulting from the feeding of rations containing different levels of prairie hay as the sole roughage.

PROBLEM

The purpose of this study is to determine the effect of feeding different levels of prairie hay on the growth and development of Jersey heifers. It is based on the records of twenty-seven heifers used in Project 287 of the Oklahoma Experiment Station. All the heifers were grade Jerseys, some of them being transferred from Project 190 of the Oklahoma station when Project 287 was started in September 1, 1936. Most of the heifers were the progeny of cows used in Projects 190 and 287 born between September 1, 1936 and January 1, 1939. All heifer calves from cows in Project 190 were transferred to Project 287 at the time of birth. These grade heifers were started on the experimental ration used in this study at various times from September 1, 1936 to January 1, 1939.

Due to the fact that the experiment is still in progress and the data used in this study were obtained from heifers ranging in age from six to twenty-four months, it is necessary to present the data at the various age intervals. In view of this fact the data include feed and growth records for twenty heifers from birth to six months of age, fifteen heifers to twelve and eighteen months of age, and thirteen heifers to twenty-four months of age. Additional data concerned with the feed and growth records of nineteen heifers for the first gestation period is also included in this study.

As a general rule, these heifers were fed whole milk for the first six weeks, and then gradually changed to skim milk. The skim milk was fed to the age of six months. These heifers were confined in individual stalls in the college dairy barn until they were six months old, and following that time were turned out in a dry lot after each of the two daily feedings. The only exceptions to this practice were short periods of

inclement weather when it became necessary to confine the heifers indoors during the entire day.

Amounts of total digestible nutrients furnished by this experimental ration are based on the Minnesota feeding standard for normal growth of dairy heifers.(12)

Prairie hay was the only roughage fed and rations were formulated in which three different levels of hay were used.

The standard, or 100 percent prairie hay ration used in this study, was based on the records of average daily hay consumption of grade Jerseys fed prairie hay, ad libitum, in Project 190 of the Oklahoma Experiment Station as reported by Kuhlman. (19)

A second ration which allowed the consumption of one-half the amount of prairie hay fed in the 100 percent hay ration was designated as the 50 percent hay ration. The third ration allowed the consumption of one-fourth the amount of prairie hay used in the 100 percent hay ration and was designated as the 25 percent hay ration. At any given age, the three hay rations were supplemented with equal amounts of cottonseed meal, namely such an amount which will meet the protein requirements for normal growth based on the Morrison standard.^{1/}

In addition to the cottonseed meal, dried beet pulp was fed with each of these three rations in such quantities that the total digestible nutrients supplied by all three rations were equivalent in amount.

The heifers were started on prairie hay, dried beet pulp, and cottonseed meal as soon as they showed a desire to eat these feeds. Some of the heifers did not eat both hay and concentrates until the latter part of the first thirty-day period while others did not eat very much of

^{1/} F. B. Morrison, "Feeds and Feeding," 20th edition, p. 1005.

either feed until the second thirty-day period, or when they were between 30 and 60 days of age. All of the heifers were weighed and measured for height at withers for three consecutive days at regular ten-day intervals. All weights and measurements used in this study are the averages of the records for each three day period respectively.

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REVIEW OF LITERATURE

The feeding of rations which will produce normal growth and development in young dairy heifers has been the subject of research by several experiment station investigators. Various types of rations have been fed. Several attempts have been made to raise calves by feeding rations containing no roughages. Such rations consisted entirely of milk or milk plus concentrates. Work conducted by Herman (16), Ragsdale (27) and McCandlish (21) in which either whole milk or skim milk was fed as the primary source of nutrients in the ration produced normal, and in some cases, above normal gains during the first several months of the calves' lives. As the calves grew older this type of a ration proved to be inadequate for normal gains. The calves failed to grow at the normal rate and some actually lost weight. Several developed symptoms of anemia, and in practically all cases death occurred somewhere between the age of 11 to 14 months.

Research in regard to the feeding of concentrate rations to growing dairy calves has been conducted by Davenport (9), Huffman (17), Mead (22), Reed (28), and others. The feeding of this type of ration has, in general, produced normal growth from birth to six months, and in some cases up to the age of eight or ten months. Sometime between the ages of six months and a year abnormal symptoms have developed in the calves indicating a deficiency of some essential element in the ration. Unless these deficiencies were corrected by a change in the ration, the calves continued to decline in health and death occurred as the final result.

Studies concerning the value of roughages in the ration for obtaining normal growth in dairy heifers are varied in nature.

Early work done by Hart (14) indicated differences in the feeding

value of the forage of three cereal grains for producing normal growth and reproduction in grade Holstein heifers.

Copeland (7) conducted a study to determine the value of cottonseed hulls and hay as roughages for growing Jersey heifers. Two lots each containing twenty-three grade and purebred Jersey heifers were used as experimental subjects. Lot I received Bermuda, Sudan, and Sorghum hays as the dry roughage, while Lot II received cottonseed hulls. Both rations were supplemented with grain, silage, and pasturage when available. Lot I fed the hay as the dry roughage made the more rapid growth during the first 18 months, and especially from six to nine months of age. At the age of 21 months the animals in Lot I, on the average, were 50 pounds heavier than those in Lot II, and also exceeded them in the majority of the body measurements taken.

Beam (2) conducted a short time (126 days) feeding experiment with eight dairy heifers in which oat feed was substituted for one-half the daily hay ration. When compared with a similar lot of heifers fed a hay ration, the average daily gain was 1.16 pounds for the oat feed lot and 1.24 pounds for the hay-fed lot. The gain in height at withers was 10.22 and 10.25 centimeters respectively. Both lots received silage and the same grain mixture.

Willard (30) conducted a winter feeding experiment over a period of 150 to 203 days in which dairy heifers ranging in age from 16 to 20 months were respectively fed rations of native hay, alfalfa hay, and both kinds of hay plus silage. In the lot fed the native hay alone none of the heifers made normal gains, and the average gain for the period was about two-thirds of normal as compared to the lot fed alfalfa hay alone in which three-fourths of the heifers made normal gains or better, and the average

gain was slightly above normal.

Results of experiments by Meigs (23), and Bechtel (3) in which poor quality timothy hay was fed to young dairy calves show that roughage of such quality contained insufficient amounts of vitamin A to promote normal growth; as the calves developed symptoms of vitamin A deficiency, which if not corrected, resulted in death. Some work more closely related to this study of the value of prairie hay in the rations of growing dairy calves was conducted by Cave (6) at the Kansas Station. He fed dairy calves prairie hay ad libitum plus a vitamin A deficient grain mixture and milk from dams fed similar rations. These cross-bred Ayrshire-Holstein calves made an average gain of 226 pounds in body weight from birth to six months of age, appeared thrifty, and reacted normally in all respects. The night blindness test for vitamin A deficiency showed no abnormalities in that respect.

Kuhlman (18) fed prairie hay ad libitum supplemented by cottonseed meal as the sole concentrate to more than fifty grade Jersey calves during the ten year period, 1927-1937, and obtained very favorable results in regard to growth and development. No apparent symptoms of vitamin A deficiency were manifested even when low grade prairie hay produced during drouth seasons were fed.

Dvorachek (10) conducted a feeding trial with growing dairy heifers. Six Holstein and three Jerseys about five months of age were selected as experimental subjects, and divided into three lots. Lot I received alfalfa hay and Lots II and III received prairie hay as the sole roughage. All three lots received the hay ad libitum plus a basal concentrate ration consisting of white corn chops, ground brewer's rice and salt. Lot II

received the basal concentrate ration supplemented by linseed oil meal and steamed bone meal. Lot III received the same concentrate ration as Lot II plus a cod liver oil supplement. At the approximate age of twenty-two months, the heifers in Lots II and III had made equal, and even slightly larger gains than the heifers in Lot I which were fed alfalfa hay plus the basal concentrate ration. Lots II and III made almost identical gains in weight and body measurements indicating that the ration fed Lot II was adequate in the vitamins supplied to the ration of Lot III by the addition of the cod liver oil supplement.

In addition to the studies concerning the effects of different types of rations in influencing growth and development of young dairy cattle, other factors affecting growth have also been considered. Bartlett (1), Espe (13), and Ragsdale (24, (25) have formulated normal growth standards for dairy cattle based on the records of a large number of dairy cattle raised under quite favorable conditions in experiment station herds. The Bartlett (1), and Espe (13) standards are based on records made at the Reading England and Iowa stations respectively, while Ragsdale's (25) are based on records made at several experiment station and large breeder's herds.

Lush (20) conducted a study pertaining to normal growth of range cattle and his results show the influence which season and feed supply have on growth in weight and skeletal measurements of young beef cattle raised under range conditions.

Eckles (11) studied the influence upon the rate of growth of dairy heifers of rations containing liberal and insufficient amounts of total digestible nutrients.

Eckles (12) also studied nutrient requirements for normal growth of dairy cattle by a comparison of the Wolff-Lehmann, Kellner, Armsby, and Morrison feeding standards for growing dairy heifers. The important conclusion from the comparison of these feeding standards is that the Morrison standard was found to be too low for normal growth of dairy heifers under one year of age and too high beyond that age.

Ragsdale (26) studied feed consumption of dairy cattle during the growth period. His results show that Jersey heifers consumed 281.0, 608.0, 1089.0 and 1054.0 pounds of total digestible nutrients per 100 pounds of gain in weight at the respective ages of six, twelve, eighteen, and twenty-four months.

Carneiro (5) conducted growth studies with purebred Holstein calves in Brazil. After the age of four months these calves showed a decreased rate of growth when compared with the normal (Eckles) standards. Under similar conditions of feeding and management crossbred Holstein-Brahama calves developed normally, and it was concluded that environmental conditions other than nutrition are responsible for the subnormal rate of growth of the purebred calves.

PLAN OF STUDY

The plan used in this study was to calculate the percent of normal growth and development made by Jersey heifers fed different levels of prairie hay as the sole roughage.

Growth, as interpreted in this study, is the increase in pounds of body weight and centimeters in height at withers. The weights and heights of all heifers is expressed as a percentage of the Missouri normals for Jerseys (25) by thirty-day periods from birth to the age of twenty-four months. Weight and height percentages for heifers under two years of age were calculated on the same basis, the only difference being in the number of months that data was available for the younger heifers. The total digestible nutrient intake was expressed in the same manner using the Minnesota standard (12) as the normal basis for the calculations.

Studies pertaining to gains made during the first gestation period are based on the schedule used in feeding these heifers during that period.

All studies of feed intake and growth are based on 30 day periods. Individual records were obtained for each of the animals. They were summarized by lots according to the level of prairie hay which had been fed. All heifers fed the 25 percent hay ration, which had made apparently normal gains and showed no development of visible symptoms of vitamin A deficiency, were designated as Lot I. Heifers fed the 50 percent hay ration, and developed normally, were designated as Lot II, and heifers fed the 100 percent, or standard hay ration, as Lot III. Lots IV, V, and VI are individual heifers which developed symptoms of vitamin A deficiency when fed the limited prairie hay rations. Lot VII includes

three heifers fed a liberal prairie hay ration supplemented with a commercial vitamin A preparation known as Puratene.

PRESENTATION AND DISCUSSION OF RESULTS

Part I

Growth and Development of Jersey Heifers Fed Three Levels of
Prairie Hay from Birth to the End of Twenty-four Months
of Age

Gains in weight, one of the primary measures of growth, will be considered first in this discussion. Table 1 shows the average actual weights of Lots I, II, and III compared with the Missouri normal for Jerseys (25), from birth to twenty-four months inclusive. Table 2 and Figure I show these weights expressed as percent of normal based on the Missouri Standard (25), for the two year period. It may be noted that the average birth weight of Lot I (Table 1) is considerably lower than either Lots II and III or the normal, and the reason for this was the light birth weight of three of the four heifers representing Lot I. Regardless of their small size at birth, these heifers made rapid gains, and at six months of age they were as heavy as Lot III which also contained four heifers.

Lot II, represented by six heifers, made excellent gains during this early period and exceeded both Lots I and III by exactly 22 pounds in weight at the age of six months. During the seventh month, all lots show a decline in rate of gain, apparently due to the combined effects of being turned out in the exercise lot for the first time, and the removal of the skim milk from the ration. Both of these factors tend to affect the heifers, adversely, resulting in a slight decrease in feed consumption and rate of gain. After the heifers became accustomed to the changes in the ration and environment, improvement in gains were noted and during the remainder of the two year period the heifers in all three lots made very satisfactory gains. At the age of two years, Lots I, II, and III weighed

Table 1. Average Body Weights of Heifers Fed Different Levels of Prairie Hay

Age in: months:	Missouri Normal: (lbs.)	Lot I, 25% Hay: (lbs.)	Lot II, 50% Hay: (lbs.)	Lot III, 100% Hay: (lbs.)
Birth	53	44	50	52
1	67	63	63	68
2	90	88	88	86
3	121	117	122	113
4	158	148	161	148
5	199	191	202	185
6	243	228	250	228
7	286	243	269	261
8	324	265	294	296
9	360	302	328	324
10	393	332	352	359
11	420	367	388	388
12	450	406	419	424
13	479	446	446	446
14	507	480	491	484
15	530	509	513	504
16	558	533	538	529
17	580	567	562	551
18	601	600	581	567
19	622	628	602	588
20	642	655	628	619
21	665	681	660	658
22	684	707	707	678
23	708	744	737	689
24	733	793	760	718

Table II. Percent of Normal Weight Of Heifers Fed Different Levels of Prairie Hay

Age in months : Lot I, 25% Hay : Lot II, 50% Hay : Lot III, 100% Hay			
Birth	83.0	95.0	97.4
1	94.0	94.5	100.8
2	98.0	97.8	95.0
3	96.9	100.4	93.6
4	93.8	101.6	93.5
5	95.9	101.5	92.9
6	93.7	102.8	93.9
7	85.1	93.9	91.2
8	81.8	90.8	91.3
9	83.9	91.0	90.1
10	84.4	89.5	91.4
11	87.5	92.4	92.3
12	90.1	93.2	94.2
13	93.1	93.1	93.2
14	94.6	96.9	95.3
15	96.1	96.7	94.7
16	95.5	96.4	94.3
17	97.7	96.8	93.8
18	99.8	96.7	92.1
19	101.0	95.6	92.5
20	101.7	95.3	93.0
21	101.3	95.7	94.6
22	101.3	98.2	93.5
23	102.4	98.3	91.2
24	105.1	97.5	91.3

Figure I. Percent of Normal Weight of Heifers Fed Different Levels of Prairie Hay

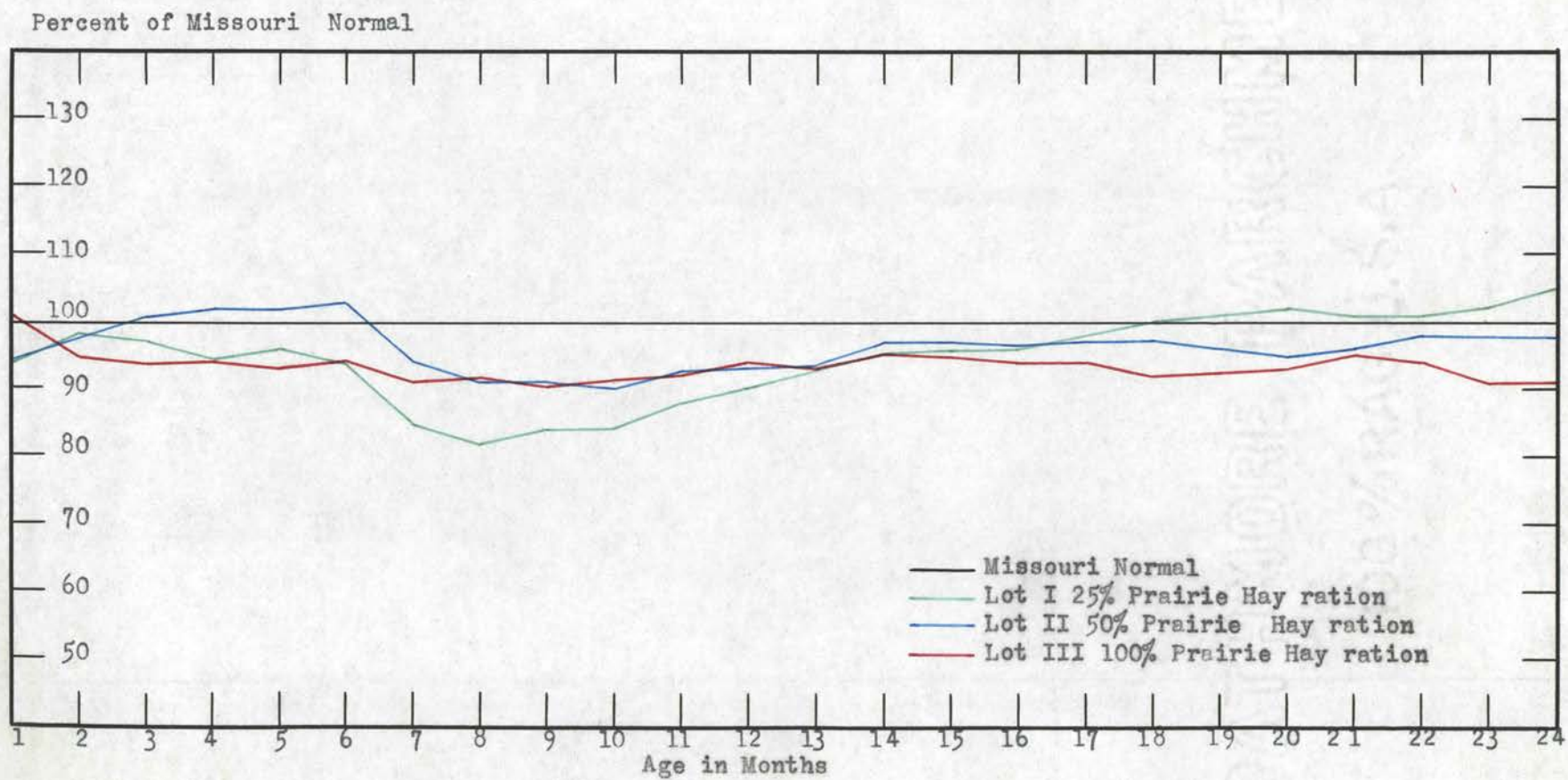
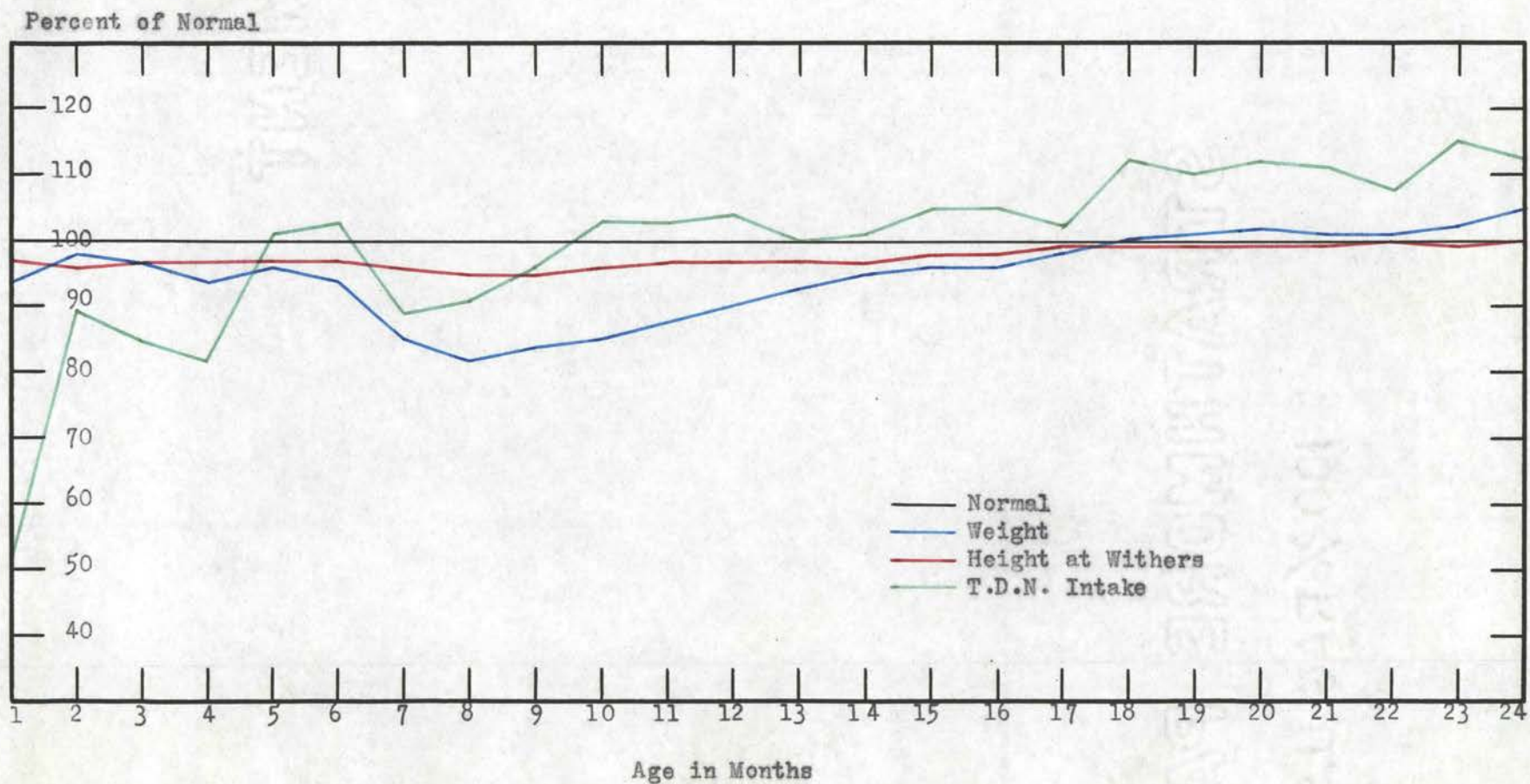


Table III. Percent of Normal Growth and T.D.N. Intake of Heifers
Fed the 25% Hay Ration

Heifers per month	Age in months	Percent of Normal		
		Weight	Height	T.D.N. Intake
4	1	94.0	96.7	52.9
4	2	98.0	96.2	89.2
4	3	96.9	96.6	85.1
4	4	93.8	97.1	82.2
4	5	95.9	97.0	100.9
4	6	93.7	97.4	102.6
3	7	85.1	95.9	89.1
3	8	81.8	94.5	91.1
3	9	83.9	94.6	96.0
3	10	84.4	95.7	102.9
3	11	87.5	96.5	102.5
3	12	90.1	96.8	103.6
3	13	93.1	97.0	99.9
3	14	94.6	97.2	101.0
3	15	96.1	98.1	105.1
3	16	95.5	97.7	105.0
3	17	97.7	98.8	102.3
3	18	99.8	98.8	112.2
3	19	101.0	99.2	109.9
3	20	101.7	98.9	111.6
3	21	101.3	98.6	110.7
3	22	101.3	99.9	107.5
3	23	102.4	99.4	114.8
3	24	105.1	99.8	112.4

Figure II. Percent of Normal Growth and T.D.N. Intake of Heifers Fed the Twenty-Five Percent Hay Ration



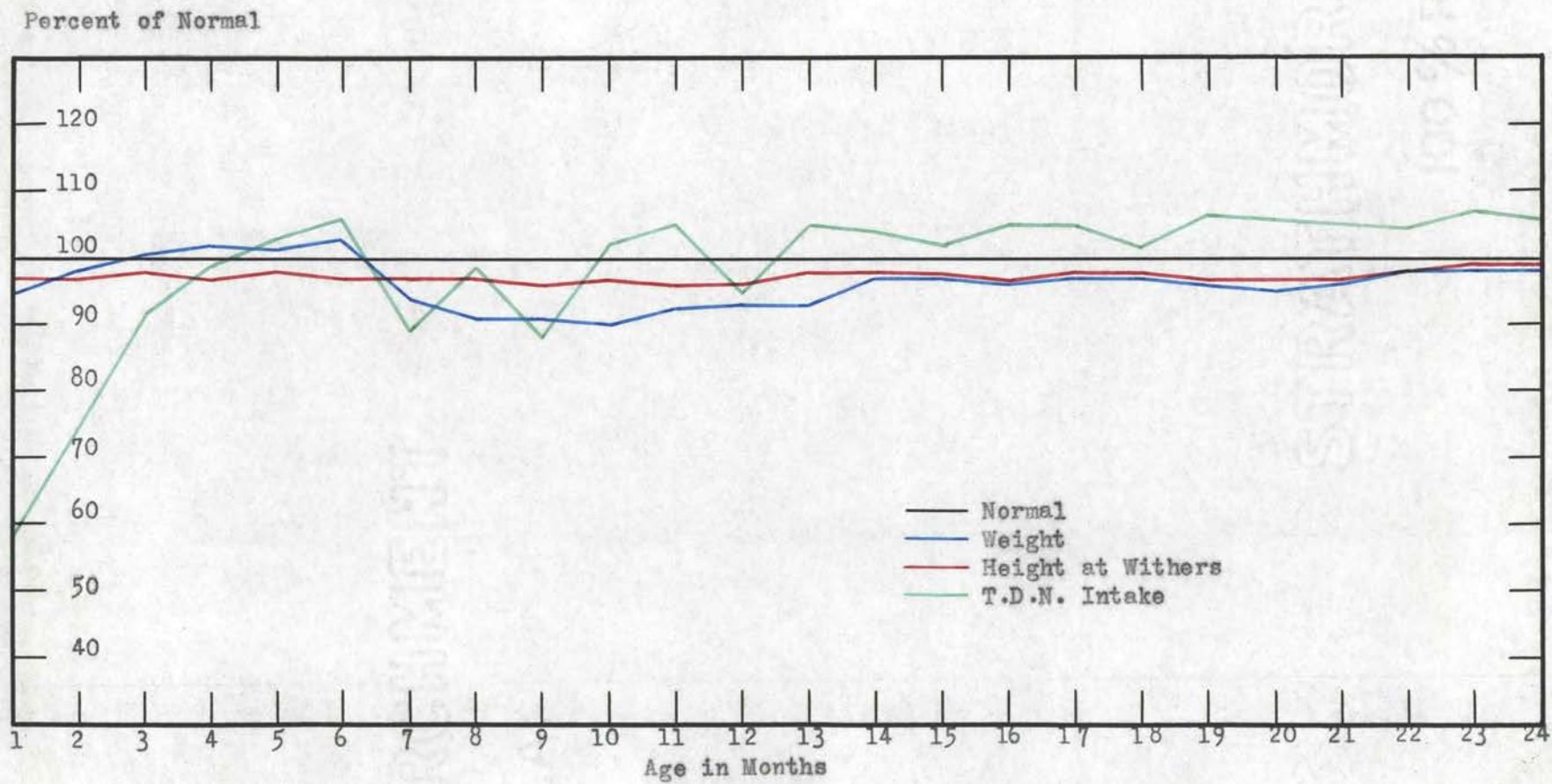
793, 760, and 718 pounds respectively, as compared to the normal of 733 pounds. Although the number of heifers in each lot is small, these gains show the possibilities of feeding limited prairie hay rations to produce normal gains in growing dairy heifers.

Since the method of feeding the three lots with reference to hay intake differs considerably from accepted practices it is of interest to consider the average gains in weight and height of each lot as related to the ration fed. The rate of gain of Lot I was very satisfactory as is shown in Table 3 and Figure II. The marked decrease which occurred from the sixth month to about the twelfth month which also occurred in Lots II and III is apparently due to the change in the ration and environment which took place during this period. Gains in height made by Lot I were also very satisfactory, and at the end of the period the lot was 99.8 percent of normal in this respect. Total digestible nutrient intake, expressed as a percent of the normal, shows greater monthly variations than is shown by weight or height. Nutrient intake did not reach the normal until the age of five months due to the fact that the young heifers often failed to consume their allotted amounts of hay and concentrates at this early age. A decline in feed intake was noticed following the sixth month due to the fact that after the removal of skim milk from the ration the heifers showed a tendency to go off-feed and some time elapsed before they became accustomed to the change of ration and began eating the allotted amounts of feed offered. After the age of seventeen months the rate of nutrient intake increased considerably. This was due to the increase in the allowance of nutrients offered in the ration beginning at that age. It is the plan of the experiment to breed the heifers when they reach the age of seventeen months, and the increased allowance of

Table IV. Percent of Normal Growth and T.D.N. Intake of Heifers
Fed the 50% Hay Ration

Heifers per month	Age in months	Percent of Normal		
		Weight	Height	T.D.N. Intake
6	1	94.5	96.6	58.2
6	2	97.8	96.9	74.2
6	3	100.4	97.9	91.2
6	4	101.6	96.9	99.1
6	5	101.5	98.1	102.8
6	6	102.8	97.3	105.9
2	7	93.9	96.9	89.1
2	8	90.8	96.8	98.4
2	9	91.0	96.0	87.6
2	10	89.5	96.9	101.7
2	11	92.4	95.9	105.3
2	12	93.2	95.7	94.6
2	13	93.1	98.0	105.4
2	14	96.9	98.0	103.9
2	15	96.7	97.5	102.0
2	16	96.4	96.5	104.8
2	17	96.8	97.7	105.2
2	18	96.7	97.9	102.2
2	19	95.6	97.3	106.4
2	20	95.3	97.2	106.1
2	21	95.7	96.5	105.1
2	22	98.2	98.0	104.5
2	23	98.3	98.6	107.2
2	24	97.5	98.7	105.9

Figure III. Percent of Normal Growth and T.D.N. Intake of Heifers Fed the Fifty Percent Hay Ration



nutrients offered after this age is for the purpose of meeting the demands of pregnancy. A comparison of the three factors show that while the 25 percent hay ration was satisfactory for producing normal gains in weight and height, it required an intake of more than normal amounts of total digestible nutrients.

The data for Lot II fed the 50 percent hay ration are presented in Table 4 and Figure III. This lot gained in weight at a more uniform rate than did Lot I. These heifers made larger gains during the first six months and were affected less by the changes in ration and environment which took place following that period. Gains made during the remainder of the two year period were very satisfactory, and the average for these two heifers of Lot II was 97.5 percent of normal at that time.

The rate of gain in height was very uniform for this lot as is noted in Figure III. The widest variation between months being only three percent, with a low of 95.7 percent at twelve months of age and a high of 98.7 percent at twenty-four months.

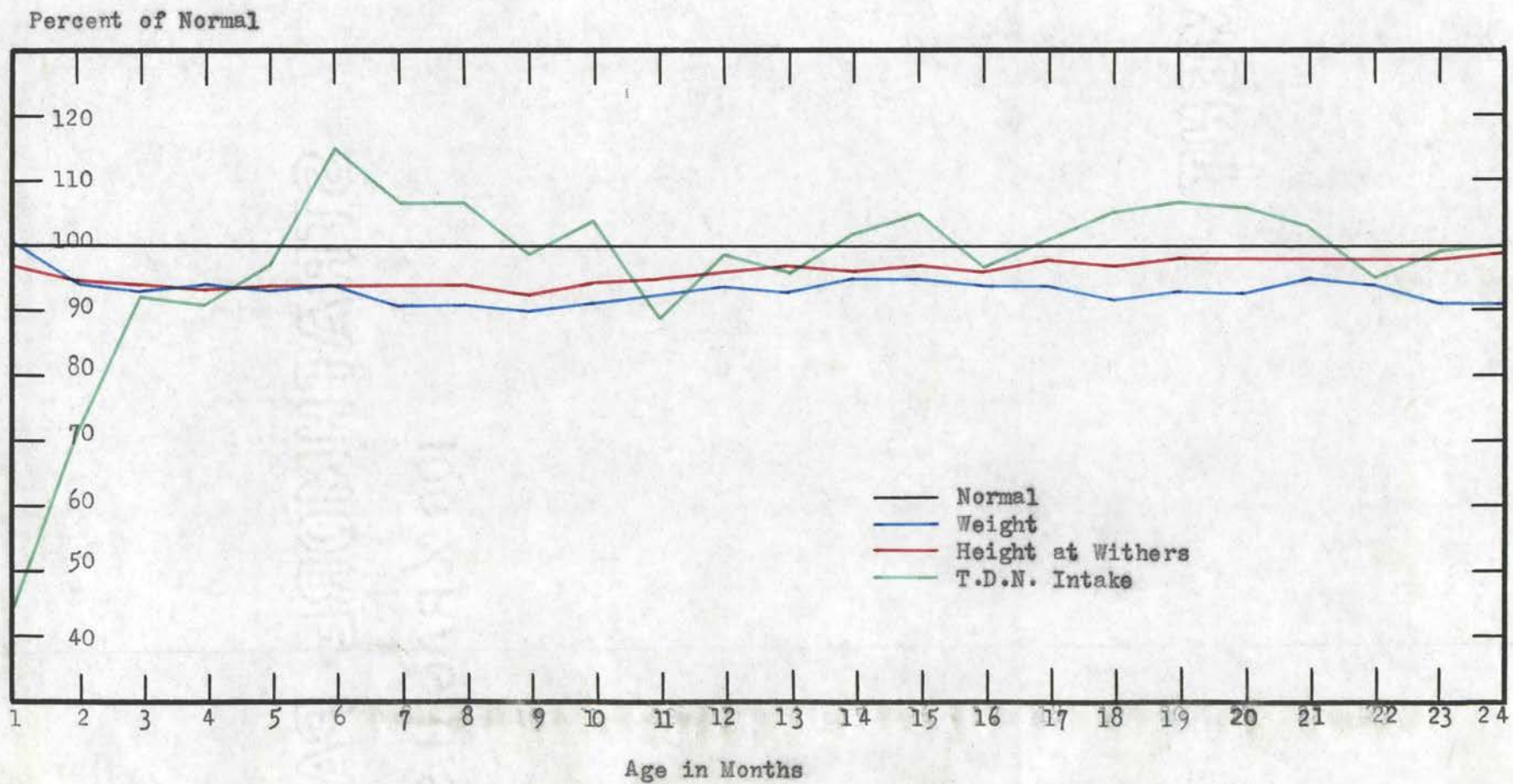
The percentages for total digestible nutrient intake show monthly variations similar to those of Lot I as can be noticed from a comparison of Figures II and III. Further comparison of these two figures indicates that the 50 percent hay ration fed Lot II was nearly as effective in producing normal growth as the 25 percent hay ration fed Lot I. In some respects it may be considered more desirable as these heifers were affected less by the changes which took place in the ration and environment following the sixth month.

During the second year, the 25 percent hay ration fed Lot I produced gains in weight and height which approached the normal more closely than did the gains made by Lot II. Feed intake was greater for Lot I during this period, especially during the latter half, as is clearly shown by

Table V. Percent of Normal Growth and T.D.N. Intake of Heifers
Fed the 100% Hay Ration

Heifers per month	Age in months	Percent of Normal		
		Weight	Height	T.D.N. Intake
4	1	100.8	97.0	44.3
4	2	95.0	95.0	70.2
4	3	93.6	94.1	92.2
4	4	93.5	93.1	91.2
4	5	92.9	94.1	96.5
4	6	93.9	94.1	114.8
4	7	91.2	94.1	107.2
4	8	91.3	93.8	106.6
4	9	90.1	93.1	99.0
4	10	91.4	94.5	103.9
4	11	92.3	95.1	89.2
4	12	94.2	96.3	99.2
4	13	93.2	97.0	95.5
4	14	95.3	96.3	102.1
4	15	94.7	96.7	104.8
4	16	94.3	96.1	97.4
4	17	93.8	97.4	101.1
4	18	92.1	97.1	105.3
2	19	92.5	98.0	106.7
2	20	93.0	97.6	106.2
2	21	94.6	97.7	103.3
2	22	93.5	98.1	94.7
2	23	91.2	98.1	98.6
2	24	91.3	98.8	99.5

Figure IV. Percent of Normal Growth and T.D.N. Intake of Heifers Fed the One Hundred Percent Hay Ration



a comparison of Figures II and III. An explanation for this difference in nutrient consumption between Lots I and II is found in the source of nutrients in the rations fed these lots. The 25 percent hay ration fed Lot I contains less hay and more dried beet pulp than does the 50 percent hay ration fed Lot II. Heifers fed the 25 percent hay ration consumed the allotted amounts of hay offered and seldom refused any of the concentrates, while the heifers fed the 50 percent hay ration consumed their entire allowance of concentrates but frequently refused small amounts of hay, and as a result, their intake of total digestible nutrients was slightly less as compared to the intake of the heifers fed the 25 percent hay ration. One reason for lower feed consumption by the heifers in Lot II is palatability; the 50 percent hay ration contains twice the amount of hay allowed in the 25 percent hay ration and consequently less dried beet pulp. The dried beet pulp is more palatable than the prairie hay, and as a result the 25 percent hay ration was consumed more completely than the 50 percent hay ration. Table 5 and Figure IV contains the data for Lot III. This lot, although two pounds heavier at birth, did not gain quite as rapidly during the first six months as did Lot II. It made gains nearly equal to those of Lot I. During the period, from six months to one year of age, Lots II and III made very similar gains exceeding Lot I in this respect. This indicates the value of the larger amounts of hay fed Lots II and III in producing normal growth during this period. During the period, from one to two years of age gains made by Lot III were very satisfactory, although not quite equal to those made by Lots I and II. Gains in height of Lot III were very uniform and showed the same trends as do those made by Lots I and II. Although slightly smaller than those of Lots I and II they were very

satisfactory and never were below 93.0 percent of normal at any time during the two-year period.

Nutrient consumption of Lot III was very similar to that of Lots I and II. One exception, however, was the more uniform feed consumption during the months immediately following the removal of the skim milk from the ration. These heifers apparently were less affected by the changes in the ration and environment than were the heifers in Lots I and II. Rates of gain in weight show a smaller decrease probably due to the fact that these heifers more nearly consumed their allotted amounts of feed.

Table 6. Feed and Weight Records from Birth to 180 Days of Heifers Fed Different Levels of Prairie Hay

	: Normal	: Lot I	: Lot II	: Lot III
Level of hay intake		25%	50%	100%
Number of animals		4	6	4
Ave. weight per animal:				
at birth, lbs.	53.0	44.0	50.3	51.6
at 180 days, lbs.	243.0	227.8	249.7	228.3
Gain, lbs.	190.0	183.8	199.4	176.7
Feeds consumed per animal:				
Whole milk, lbs.	209.0	243.5	234.8	206.0
Skim milk, lbs.	1781.0	1671.0	1776.6	1660.0
Prairie Hay, lbs.	285.0	78.5	133.5	212.9
Beet pulp, lbs.	165.0	168.2	152.8	116.8
Cottonseed meal, lbs.	165.0	160.2	164.0	155.6
Ave. lbs. T.D.N. consumed per 100 lbs. gain	298.7	255.2	245.8	271.6

Table 6 affords a comparison of each lot with the normal with reference to gains and economy of gains during the first six months. Lot II excelled the other two lots, both in the rapidity and efficiency of gains made, followed in order by Lots I and III. At this age, Lots I, II, and III had consumed 255.2, 245.8, and 271.6 pounds of total digestible nutrients, respectively, per 100 pounds gain in weight as compared to the normal requirement of 298.7 pounds.

Table 7. Feed and Weight Records from Birth to 360 Days of Heifers Fed Different Levels of Prairie Hay

	: Normal	: Lot I	: Lot II	: Lot III
Level of hay intake		25%	50%	100%
Number of animals		3	2	4
Ave. weight of Animals:				
at birth, lbs.	53.0	38.3	47.5	51.6
at 360 days, lbs.	450.0	405.7	419.0	423.8
Gain, lbs.	397.0	367.4	371.5	372.2
Feeds consumed per animal:				
Whole milk, lbs.	209.0	245.0	232.5	206.0
Skim milk, lbs.	1781.0	1702.3	1982.2	1741.9
Prairie hay, lbs.	1419.0	363.6	672.9	1233.1
Beet Pulp, lbs.	536.0	883.7	613.7	401.7
Cottonseed meal, lbs.	578.0	673.9	732.0	673.5
Ave. lbs. T.D.N. consumed per 100 lbs. gain	428.8	413.4	412.1	421.1

A comparison of the three lots from birth to one year of age is shown in Table 7. Although all three lots failed to make normal gains, Lot III made better gains than the other two lots. However, this deviation from the normal is small as Lot I which made the smallest gain, was only 19.6 pounds below normal weight. In efficiency of gain at this age, Lot II still excels. Lots I, II, and III consumed 413.4, 412.1, and 421.1 pounds of total digestible nutrients per 100 pounds gain in weight as compared to the normal requirements of 428.8 pounds.

Table 8. Feed and Weight Records from Birth to 540 Days of Heifers Fed Different Levels of Prairie Hay

	: Normal	: Lot I	: Lot II	: Lot III
Level of hay intake		25%	50%	100%
Number of animals		3	2	4
Ave. weight of animals:				
at birth, lbs.	53.0	38.3	47.5	51.6
at 540 days, lbs.	601.0	600.0	581.0	555.5
Gain, lbs.	548.0	561.7	533.5	503.9
Feeds consumed per animal:				
Whole milk, lbs.	209.0	245.0	232.5	206.0
Skim milk, lbs.	1781.0	1702.3	1982.2	1741.9
Prairie hay, lbs.	3093.0	785.4	1491.6	2558.6
Beet Pulp, lbs.	824.0	1947.7	1393.4	602.3
Cotton seed meal, lbs.	1070.0	1164.1	1249.0	1254.1
Ave. lbs. T.D.N. consumed per 100 lbs. gain	557.9	511.9	540.4	572.2

Of the three groups, Lot I made the greatest total gains averaging 13.7 pounds above normal at the age of 18 months. This shows that during the period from twelve to eighteen months of age, Lot I made large enough gains to equal and surpass both Lots II and III in weight. At this age Lots I, II, and III had consumed 511.9, 540.4, and 572.2 pounds of total digestible nutrients, respectively, per 100 pounds gain as compared to the normal requirements of 557.9 pounds.

Table 9. Feed and Weight Records from Birth to 720 Days of Heifers Fed Different Levels of Prairie Hay

	: Normal	: Lot I	: Lot II	: Lot III
Level of hay intake		25%	50%	100%
Number of animals		3	2	2
Ave. weight of animals:				
at birth, lbs.	53.0	38.3	47.5	53.3
at 720 days, lbs.	733.0	793.3	760.0	717.5
Gain, lbs.	680.0	755.0	712.5	664.2
Feeds consumed per animal:				
Whole milk, lbs.	209.0	245.0	232.5	183.4
Skim milk, lbs.	1781.0	1702.3	1982.2	1776.3
Prairie hay, lbs.	5157.0	1298.9	2442.9	4194.9
Beet pulp, lbs.	1112.0	3259.9	2335.8	776.8
Cottonseed meal, lbs.	1598.0	1689.1	1762.6	2231.9
Ave. lbs. T.D.N. consumed per 100 lbs. gain	682.2	594.1	619.8	663.5

At the age of two years Lot I had made the largest total gain in weight and exceeded lots II and III by 42.5 and 90.8 pounds, respectively. Lots I and II also exceeded the normal by 75.0 and 32.5 pounds respectively, as compared to Lot III which was 15.8 pounds below normal weight. In considering efficiency of gain for the two year period it will be noted that all lots were above normal in this respect. Lots I, II, and III consumed 594.1, 619.8, and 663.5 pounds of total digestible nutrients, respectively, per 100 pounds gain in weight as compared to the normal requirements of 682.2 pounds.

One explanation for the order in which Lots I, II, and III rank in efficiency of gain over this two year period is suggested by the source of the digestible nutrients furnished in these three rations. The heifers

fed the 25 percent hay ration received a larger portion of their nutrients in the form of concentrates, namely dried beet pulp. This also is true, although to a lesser degree, of the heifers fed the 50 percent hay ration, while the heifers fed the 100 percent hay ration received a larger portion of nutrients from the prairie hay. It is a well known fact that the total digestible nutrients present in concentrate feeds are more efficiently utilized than those present in the roughages, and results obtained from Lots I, II, and III indicate that as the amount of hay in the ration is increased from 25 to 100 percent the efficiency of gain becomes less.

Efficiency of gain, as measured by the pounds of total digestible nutrients per 100 pounds gain in weight, for all three lots at the respective ages of six, twelve, eighteen, and twenty-four months compares very favorably with the values given for Jerseys as reported by Ragsdale (26), who found that Jersey heifers fed good herd rations consumed 281.0, 608.0, 1089.0 and 1054.0 pounds of total digestible nutrients per 100 pounds gain in weight, respectively, at the ages of six, twelve, eighteen, and twenty-four months.

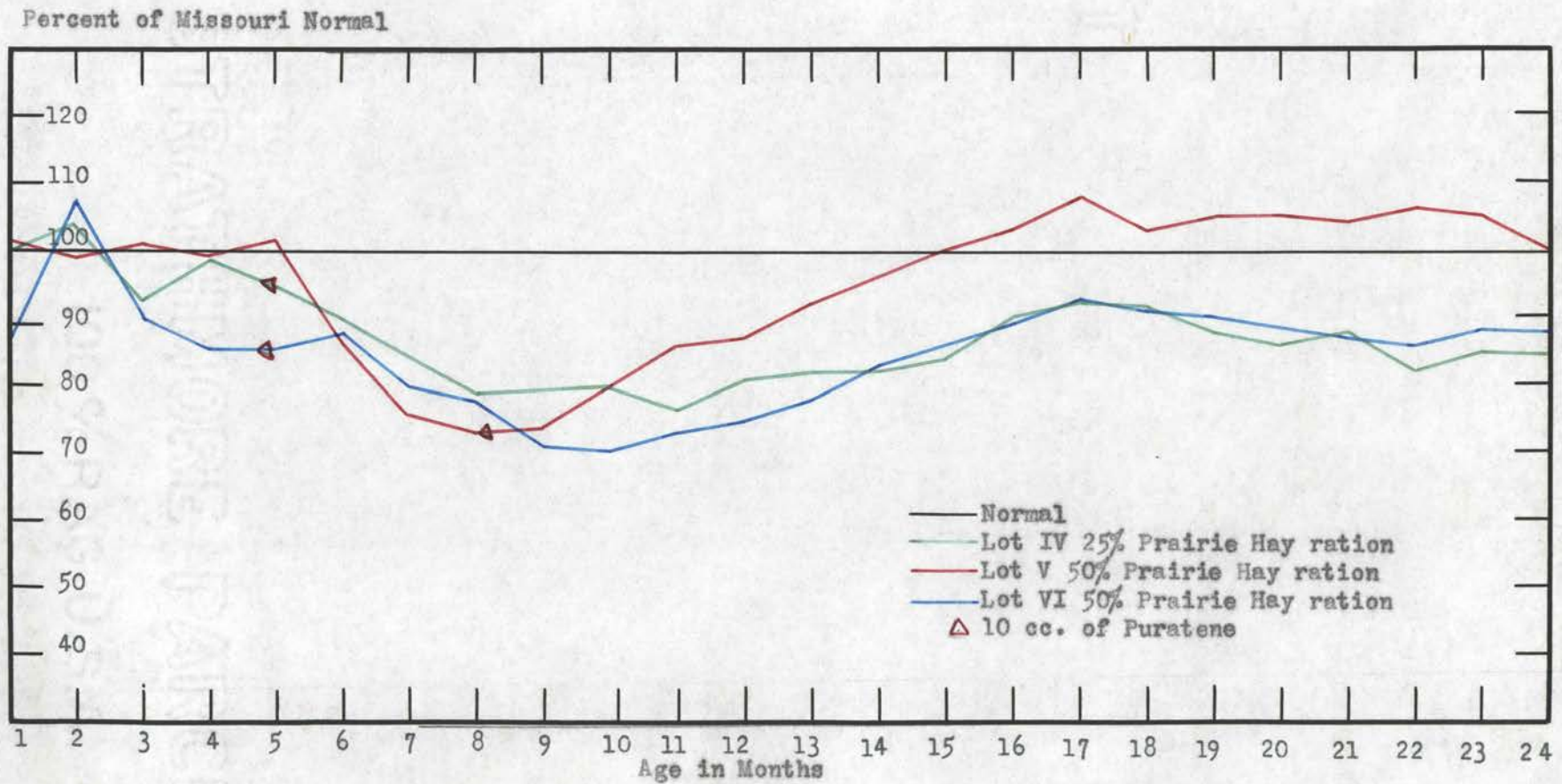
Part II.

Value of a Vitamin A Supplement in Correcting Deficiencies in Limited Prairie Hay Rations

This section deals with three heifers which developed marked symptoms of vitamin A deficiency while being fed limited prairie hay rations. A commercial vitamin A supplement in the form of 10 cubic centimeters of Puratene was added to their daily ration, and the individual response of each animal, as measured by increase in weight, together with the date of addition of the supplement to the ration is shown in Figure V.

The heifer designated as Lot IV was fed the 25 percent hay ration, and heifers designated as Lots V and VI were each fed the 50 percent hay ration. Lot IV was quite normal in weight for the first four months. The only abnormal condition noted during this period was that she bloated occasionally beginning at the age of 110 days. During the next month between the ages of 120 to 150 days, marked symptoms of vitamin A deficiency developed. At 142 days of age she was blind in the right eye and five days later blind in the left eye. At this time the eyes were bulged and gray and the pupil could not be seen. These symptoms are typical of vitamin A deficiency. Beginning at 147 days of age, she received the vitamin A supplement as shown in Figure V. Addition of the supplement to the ration corrected the appearance of the eyes, but did not restore her sight indicating that in addition to xerophthalmia, a permanent type of blindness due to constriction of the optic foramen had developed. She continued to decline in rate of gain until the age of 240 days, after which she maintained herself at this approximate level until the end of the first year. Following the age of one year she made considerable improvement in rate of gain, although she never reached

Figure V. Effect of a Vitamin A Supplement on Weight of Heifers Developing Symptoms of Vitamin A Deficiency on Limited Hay Rations



normal weight, and at the end of the two year period was still 15 percent below it.

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The heifer designated as Lot V was slightly above normal ¹⁹³⁹ weight at birth, and made very satisfactory growth during the first four months. The first symptom of vitamin A deficiency shown by this heifer was excessive coughing noticed at 105 days of age, followed later by marked symptoms during the fifth month characterized by coughing, white nasal discharges, watering of the eyes, and soreness of the joints. Following the age of 150 days, she continued to be below normal in physical condition and on the 228 and 229 day was given 60 cc of cod liver oil daily. A marked increase in body weight occurred during the following ten-day period. The abnormal condition of the eyes began to clear up, and appetite and physical condition also began to show improvement. At the age of 247 days the vitamin A supplement, Puratene, was added to the ration and shortly afterward marked improvement in the condition of this heifer was noted. Her eyes became normal and she began gaining in weight.

The response made in this respect is shown very clearly in Figure V. At the age of fifteen months, Lot V was normal in weight and during the remainder of the two year period continued to gain very satisfactorily.

The heifer designated as Lot VI was small at birth; however, she made very normal gains during the first 60 days and continued to gain following this time, although at a slower rate. Following the 120 day symptoms of vitamin A deficiency began to appear which were characterized by dullness of action, and at the age of 136 days she became blind in one eye. At the age of 147 days, she was blind in both eyes, and the eyes were bulged and gray. Additional symptoms noted were rapid breathing, secretion of excessive amounts of saliva, and sluggishness of movement.

The vitamin A supplement was added to the ration on the 147 day and some improvement in growth occurred during the following 30-day period. Addition of the supplement to the ration improved the condition of the eyes but did not restore sight, indicating a state of permanent blindness. The other deficiency symptoms were slow in clearing up. During the period from 260 to 270 days of age, additional amounts of vitamin A were given in the form of cod liver oil with little beneficial effect. This heifer, Lot VI, continued to decline in rate of gain until the age of ten months was reached, when she was only 70.5 percent of normal. After this a gradual improvement was noted until seventeen months of age, after which a slight decline occurred, and at the end of the two year period she was 88.4 percent of normal in weight.

These three heifers, Lots IV, V, and VI were born in the fall of 1936 and were fed prairie hay of the 1936 crop from the time they began eating hay until July 23, 1937 when the 1937 crop was available. The hay fed these young heifers was grown during the drouth season of 1936 and was of poor quality. A sample of it was collected for carotene determination during the period July 10 to 17, 1937, and chemical analysis showed it to have the very low carotene value of only nine tenths milligrams per pound as compared to good quality prairie hay which ranges in value from 6 to 10 milligrams per pound.

The records of these three heifers indicate the value of a vitamin A supplement in the rations of growing dairy heifers when it becomes necessary to feed limited amounts of poor quality prairie hay. Summary tables for the three lots similar to Table 6 to 9, inclusive, are shown in Part III furnishing a comparison of lots IV, V, VI, and VII.

Part III

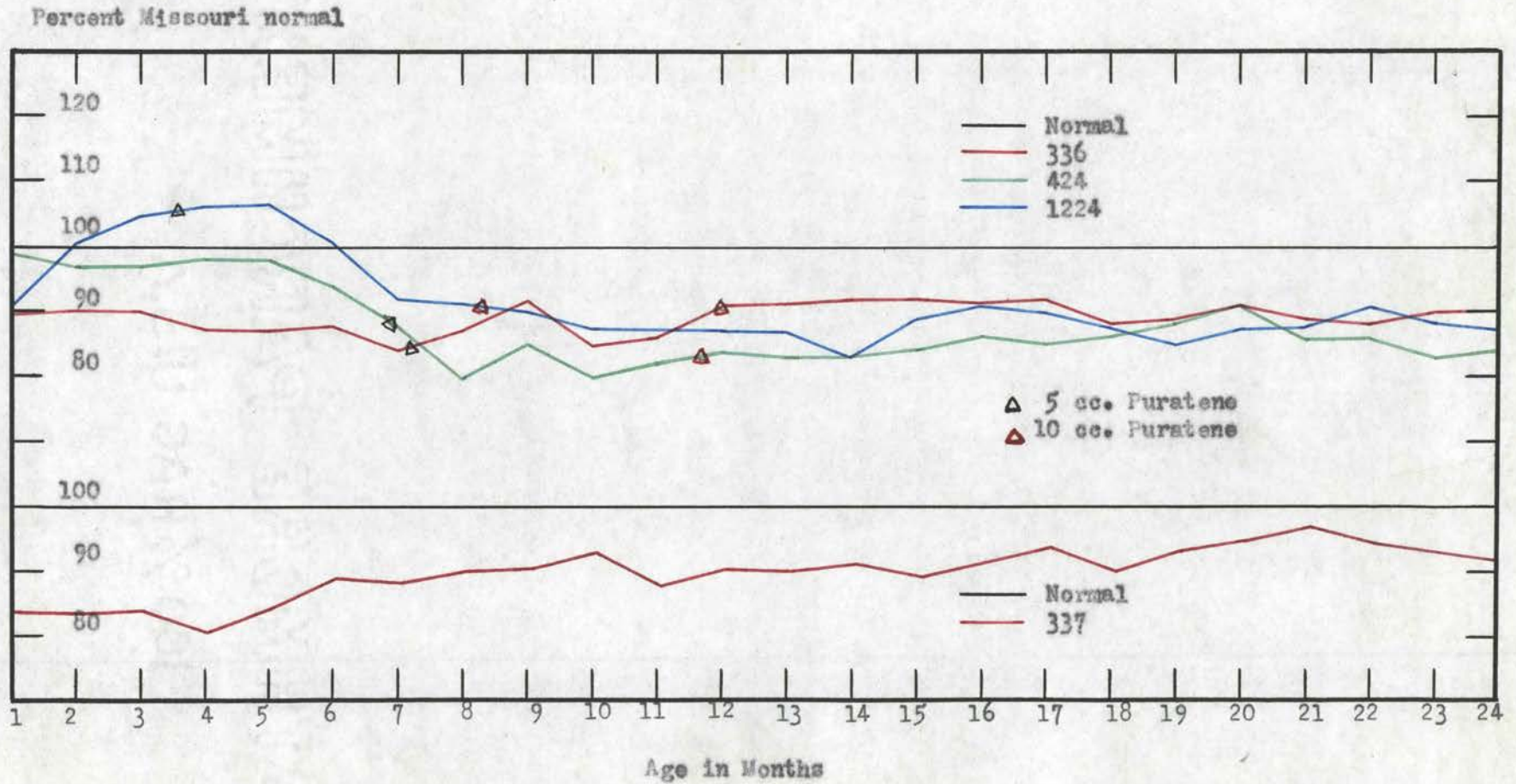
A Vitamin A Supplement Not Necessary in the Ration of Heifers
Fed Liberal Quantities of Prairie Hay

Figure VI shows the gains in weight made by three heifers fed a liberal prairie hay ration plus a vitamin A supplement. It also shows a comparison of these three heifers with another heifer of similar age which received the same hay ration without the supplement.

The three heifers which received the supplement are grouped together as Lot VII; however, for purposes of comparison in Figure VI they are designated by their individual herd numbers. These three heifers were about the same age, 336 was born July 28, 1935, 424 on August 5, and 1224 on November 15 of the same year. Heifer, number 337, fed no supplement was born July 20, 1935. All four heifers received the same rations, prairie hay, ad libitum and cottonseed meal until March 1, 1936, when 5 cc. of Puratene was added to the daily rations of 336, 424, and 1224. This amount was increased to 10 cc. daily on July 21, 1936 and fed in that amount during the remainder of the two year period. Rations of all four heifers were modified to a certain degree January 1, 1937 when dried beet pulp was substituted in the ration for a portion of the cottonseed meal. The prairie hay allowance remained the same, however, and during the entire two year period these heifers were allowed as much hay as they would consume.

The four heifers were fed the 1935 crop of prairie hay until the approximate age of one year and the 1936 crop during the second year. The 1935 crop was good quality hay grown under quite normal climatic conditions, while the 1936 crop was of poor quality as previously discussed in Part II.

Figure VI. Growth of Heifers on Liberal Hay Ration Not Improved by Vitamin A Supplement



In considering the gains made in weight by these four heifers as shown in Figure V I, it will be noted that heifer 337 which received no supplement was more nearly of normal weight than was the average weight of the three heifers fed the additional vitamin A. This indicates that the feeding of liberal amounts of good quality prairie hay furnishes sufficient vitamin A for normal growth in dairy heifers up to the age of one year.

A comparison of the rate of gain made in weight during the second year shows a condition similar to that of the first year, and at the end of the two year period heifer 337, who received no supplement, exceeded the other three heifers in percent of normal weight. These results indicate that even prairie hay of poor quality, if feed in liberal amounts, furnished sufficient amounts of vitamin A to prevent the development of any deficiency symptoms in growing dairy heifers and is in agreement with the work reported by Kuhlman (18).

Summary Tables 10 to 13, inclusive, show a comparison of Lots IV, V, VI, and VII in regard to total gains made in weight, amounts of feeds consumed, and efficiency of gain as measured by pounds of total digestible nutrients consumed per 100 pounds of gain at the ages of 180, 360, 540, and 720 days, respectively.

Table 10. Feed and Weight Records from Birth to 180 Days of Heifers
Which Developed Symptoms of Vitamin A Deficiency on Limited
Prairie Hay Rations and Heifers Fed Liberal Amounts of
Prairie Hay

	: Normal	: Lot IV	: Lot V	: Lot VI	: Lot VII
Level of hay intake		25%	50%	50%	Liberal
Number of animals		1	1	1	3
Ave. weight of animals:					
at birth, lbs.	53.0	53.0	54.0	41.0	50.3
at 180 days, lbs.	243.0	219.0	211.0	214.0	229.0
Gain, lbs.	190.0	166.0	157.0	173.0	178.7
Feeds consumed per animal:					
Whole milk, lbs.	209.0	298.1	276.5	263.5	259.1
Skim Milk, lbs.	1781.0	1517.8	1680.1	1511.9	1851.0
Prairie hay, lbs.	285.0	102.3	144.4	143.6	204.1
Beet pulp, lbs.	165.0	199.8	195.3	170.3	--
Cottonseed meal, lbs.	165.0	195.7	173.9	182.9	222.6
Ave. lbs. T.D.N. consumed per 100 lbs. gained	298.7	314.5	339.3	289.8	259.7

A consideration of Table 10 shows that Lots IV, V, and VII which developed symptoms of vitamin A deficiency during this early age, were considerably lighter in body weight than Lot VII in which the heifers developed ⁱⁿ a normal manner. Efficiency of gains for Lots IV, V, and VI are also lower as is clearly shown in Table 10. These two conditions can be explained by the fact that any condition or factor which affects growing heifers adversely will tend to decrease the rate of growth and, therefore, indirectly the efficiency of gain.

Table 11. Feed and Weight Records from Birth to 360 Days of Heifers Which Developed Symptoms of Vitamin A Deficiency on Limited Prairie Hay Rations and of Heifers Fed Liberal Amounts of Prairie Hay

	: Normal	: Lot IV	: Lot V	: Lot VI	: Lot VII
Level of hay intake		25%	50%	50%	Liberal
Number of animals		1	1	1	3
Ave. weight of animals:					
at birth, lbs.	53.0	53.0	54.0	41.0	50.3
at 360 days, lbs.	450.0	364.0	393.0	339.0	393.7
Gain, lbs.	397.0	311.0	339.0	298.0	343.4
Feeds consumed per animal:					
Whole milk, lbs.	209.0	298.1	276.5	263.5	259.1
Skim milk, lbs.	1781.0	1517.8	1680.1	1511.9	1851.0
Prairie Hay, lbs.	1419.0	386.8	678.2	624.5	1351.3
Beet pulp, lbs.	536.0	1055.7	879.8	846.4	--
Cottonseed meal, lbs.	578.0	529.3	567.4	553.1	899.3
Ave. lbs. T.D.N. consumed per 100 lbs. of gain	428.8	495.8	468.3	506.7	440.1

Table 11 compares the same lots at one year of age indicating a condition very similar to that given in the preceding table. One difference, easily noted, is the favorable response made by Lot V which at this age is only seven-tenths of a pound lighter in body weight than the average of Lot VII which received on adequate amount of vitamin^A during the first year. Lot V is also more efficient than lots IV or VI and is excelled only to a small degree by Lot VII.

During the first twelve months, all lots appeared to be less efficient in making gains as, compared to the normal, than they were during the first six months. At six months of age Lots IV, V, VI, and VII had

consumed 314.5, 339.3, 289.8, and 259.7 pounds of total digestible nutrients, respectively per 100 pounds gain as compared to the normal requirements of 298.7 pounds whereas at the age of one year these four lots had consumed 495.8, 468.3, 506.7, and 440.1 pounds respectively, as compared to the normal requirements of 428.3 pounds.

Table 12. Feed and Weight Records from Birth to 540 Days of Heifers
Which Developed Symptoms of Vitamin A Deficiency on Limited
Prairie Hay Rations and of Heifers Fed Liberal Amounts
of Prairie Hay

	: Normal	: Lot IV	: Lot V	: Lot VI	: Lot VII
Level of hay intake		25%	50%	50%	Liberal
Number of animals		1	1	1	3
Ave. weight of animals:					
at birth, lbs.	53.0	53.0	54.0	41.0	50.3
at 540 days, lbs.	601.0	550.0	618.0	548.0	528.7
Gain, lbs.	548.0	497.0	564.0	507.0	478.4
Feeds consumed per animal:					
Whole milk, lbs.	209.0	298.1	276.5	263.5	259.1
Skim milk, lbs.	1781.0	1517.8	1680.1	1511.9	1851.0
Prairie hay, lbs.	3093.0	1491.3	1496.9	1485.7	2823.4
Beet pulp, lbs.	824.0	1663.1	1683.4	1642.7	134.8
Cottonseed meal, lbs.	1070.0	1050.8	1059.2	1042.3	1871.2
Ave. lbs. T.D.N. consumed per 100 lbs. of gain	557.9	572.2	521.0	566.8	634.0

The data for all lots to the end of eighteen months are shown in Table 12. A comparison of Tables 11 and 12 show the changes which took place during the period, twelve to eighteen months. Lots IV, V, and VI made a relatively more rapid gain during this period than did Lot VII and at this age were heavier in body weight. This condition is very similar to that shown in Table 8 for Lots I, II and III. At this age Lots IV, V, and VI also show more efficient gains than does Lot VII as they consumed 572.2, 521.0 and 566.8 pounds of total digestible nutrients per 100 pounds gain in weight respectively, as compared to Lot VII which

consumed 634.0 pounds for an equal gain in weight. Lot V, the heifer which responded so favorably to the addition of vitamin A to her ration, is remarkable in this respect as she had consumed 521.0 pounds of total digestible nutrients per 100 pounds gain as compared to the normal requirement which allows the consumption 557.9 pounds per 100 pounds gain in weight.

Table 13. Feed and Weight Records from Birth to 720 Days of Heifers Which Developed Symptoms of Vitamin A Deficiency on Limited Prairie Hay Rations and of Heifers Fed Liberal Amounts of Prairie Hay

	: Normal	: Lot IV	: Lot V	: Lot VI	: Lot VII
Level of hay intake		25%	50%	50%	Liberal
Number of animals		1	1	1	3
Ave. weight of animals:					
at birth, lbs.	53.0	53.0	54.0	41.0	50.3
at 720 days, lbs.	733.0	657.0	771.0	680.0	677.3
Gain, lbs.	680.0	604.0	717.0	639.0	627.0
Feeds consumed per animal:					
Whole milk, lbs.	209.0	298.1	276.5	263.5	259.1
Skim milk, lbs.	1781.0	1517.8	1680.1	1511.9	1851.0
Prairie hay, lbs.	5157.0	1337.1	2517.3	2235.2	4388.1
Beet pulp, lbs.	1112.0	3218.5	2582.4	2524.9	477.3
Cottonseed meal, lbs.	1598.0	1443.3	1552.2	1560.1	2574.2
Ave. lbs. T.D.N. consumed per 100 lbs. gain	682.2	708.8	621.5	668.8	725.8

Table 13 shows the results obtained to the end of the two year period. At this age Lots V and VI exceeded Lot VII in total gain in weight. Lot V also exceeded the normal weight by 37 pounds. Lot IV, the heifer fed the 25 percent hay ration supplemented with vitamin A, made the smallest gain of all, and at this age is 76 pounds below normal weight. Lot VII, the three heifers fed the liberal hay ration supplemented with vitamin A, made quite satisfactory gains. However, they were not as large as one might expect from the feeding of a ration which furnished large amounts of both roughage and vitamin A.

In comparing the efficiency of gain made by these four lots, it will

be noted that Lots V and VI excel Lots IV and VII, and are above normal in this respect. Lot IV, the heifer which made a smaller total gain in weight during the two year period, was also less efficient in the utilization of the total digestible nutrients consumed. A comparison of her total digestible nutrient intake with the normal shows that she consumed 26.6 pounds in excess of normal requirements for each 100 pounds gain in body weight. Two undesirable results, decrease rate of growth and low efficiency of gain of this heifer as a result of the effects of vitamin A deficiency stress the importance and value of sufficient amounts of vitamin A in the rations for growing dairy heifers.

Lot VII was less efficient than any of the other three lots which received the limited hay rations. These heifers, on the average, consumed 43.6 more pounds of total digestible nutrients per 100 pounds gain in weight than the normal requirement at this age. One logical explanation for the lower efficiency of gain by Lot VII is that this group received a large portion of the total digestible nutrients in the form of prairie hay as compared to Lots IV, V, and VI which received a larger portion of the nutrients in the form of concentrates. Thus, these results tend to verify the fact that rations furnishing a major portion of the total digestible nutrients in the form of concentrates are more efficiently utilized than rations furnishing the major portion of nutrients in the form of roughages.

Part IV

Different Levels of Prairie Hay As the Sole Roughage During the First Gestation Period

The gains in weight, feeds consumed, and the relative efficiency of gains by Lots I to VII, inclusive, during the first gestation period are shown in Table 14 and 15.

Lots I and II contain several heifers in addition to the number included in the growth studies for the two year period discussed in Part I. The additional heifers were transferred from another project and changed from a full allowance of prairie hay to the 25 and 50 percent hay rations at the time of conception. Data obtained during their first gestation period were therefore included in this phase of the study. During the first gestation period it was the plan of the investigators to feed all of the heifers rations which would supply sufficient amounts of total digestible nutrients to make an average daily gain of one pound in body weight. Rations which would give this rate of gain were based on the actual gains made by a large number of grade Jersey heifers during the first gestation period when fed prairie hay, ad libitum, and cottonseed meal rations in Project 190 of the Oklahoma Experiment Station.

This group of heifers made an average daily gain of approximately one pound during the first gestation period. Since growth and development were very satisfactory, it was decided to feed the heifers in this study an equivalent amount of total digestible nutrients during their first gestation period.

Table 14. Feed and Weight Record of Heifers Fed Different Levels of Prairie Hay During the First Gestation Period

	: Lot I	: Lot II	: Lot III
Level of hay intake	25%	50%	100%
Number of animals	6	5 ^{1/}	2
Ave. weight of animals:			
at conception, lbs.	677.7	647.8	550.5
at calving, lbs.	982.3	924.2	804.5
Gain, lbs.	304.6	276.4	254.0
Length Gestation in days	274.7	271.2	267.0
Daily gain, lbs.	1.11	1.02	.95
Feeds consumed:			
Prairie hay, lbs.	901.9	1635.0	2500.6
Beet pulp, lbs.	1894.1	1305.5	453.0
Cottonseed meal, lbs.	1066.1	1195.7	924.9
Total lbs. T.D.N. per animal	2630.2	2635.7	2207.0
Ave. lb. T.D.N. consumed per 100 lbs. gain	863.4	953.6	868.9

^{1/} Data for one heifer in this lot used only to the 240 day of pregnancy.

A comparison of Lots I, II, and III is shown in Table 14. Lot I fed the 25 percent hay ration was heavier than either Lots II or III at the time of conception, and also made a larger total gain during the gestation period. The average length of the gestation period for these six heifers was 274.7 days and they made an average daily gain in weight of 1.11 pounds during this period. This daily gain is slightly in excess of the amount expected and indicates that the 25 percent hay ration when supplemented with sufficient amounts of total digestible nutrients in the form of concentrates, is very effective in producing gains during

the first gestation period.

Lot II fed the 50 percent hay ration made a very satisfactory gain during the gestation period, and all heifers excepting one behaved normally. This particular heifer was normal in all respects until about the 240 day of her gestation period, and had gained a total of 257 pounds in weight at that time. Following this period she became abnormal, lost her appetite, and began losing weight. On the 261 day of the gestation period she aborted and continued to be abnormal. In view of the existence of these abnormal conditions after the 240 day it was decided that data obtained subsequently to that time should be included. Omitting the last part of the gestation period for this one heifer, Lot II represented by five heifers made an average daily gain of 1.32 pounds. This gain exceeded the expected by .02 of a pound and indicates that the 50 percent hay ration is entirely satisfactory for producing the desired gains during the first gestation period.

Lot III represented by only two heifers, made the smallest gain of the three lots, and also had the shortest gestation period due to the fact that one of the two heifers calved on the 260 day of pregnancy. These two heifers made an average daily gain of 95 hundredths of a pound during the period which is only slightly less than the expected gain. The gain made by heifers in Lot III fed the 100 percent hay ration can be considered quite satisfactory for producing the desired gains during the first gestation period. The records of feed consumption of these three lots as shown in Table 14 show that more pounds of total digestible nutrients were consumed per animal in Lots I and II than in Lot III. Two explanations for the different in nutrient intake are: first, the heifers in Lots I and II were considerably heavier at the time of conception as compared to

the two heifers in Lot III, and secondly, the greater gains made by the Lots I and II. Considering the efficiency of gain of the three lots as shown by the nutrient intake per 100 pounds gain it is noted that Lot I excels in this respect, followed closely by Lot III, both being considerably more efficient than Lot II. Table 14 shows that Lots I, II, and III consumed 863.4, 953.6 and 868.9 pounds of total digestible nutrients, respectively, per 100 pounds gain in weight during the first gestation period. The more efficient gains made by Lot I as compared to Lots II and III is explained by the differences in the rations fed. The 25 percent hay ration fed Lot I furnishes a larger portion of the total digestible nutrients in the form of concentrates than does either the 50 and 100 percent hay rations fed Lots II and III, respectively. Results obtained throughout this entire study indicate that the nutrients furnished in this 25 percent hay ration are more efficiently utilized than those furnished in the 50 and 100 percent hay rations.

In efficiency of gain, Lot III follows Lot I although the difference is very small which indicates that these two heifers were practically as efficient in the utilization of the nutrients furnished in the 100 percent hay ration as were the heifers in Lot I fed the 25 percent hay ration. However, the heifers of Lot III had two advantages over those of Lot I, namely, their actual age and weight at the time of conception. The average age in days and pounds in weight for Lot III were 524 and 550.5, respectively, as compared to the average age in days and pounds in weight for Lot I which were 601.2 and 677.7, respectively.

Both factors, younger age and lighter weight, should produce more efficient gains as younger heifers gain faster than more mature heifers and these differences in age and weight are a logical explanation for the

efficient gains made by the two heifers representing Lot III.

Lot II was the least efficient of the three lots, as it consumed 90.2 and 84.7 pounds of total digestible nutrients more than did Lots I and III, respectively. This rate of efficiency of gain by Lot II is contrary to the expectation. However, due to the differences between the rations fed Lots I and II it is logical to expect that Lot I would exceed Lot II in efficiency of gain, and the results show this to be the case. Lot III excelled Lot II in efficiency of gain which was not expected. This marked difference is shown in Table 14. One possible explanation for this occurrence is the difference between the average age and weight of the heifers represented in Lots II and III. Heifers in Lot II averaged 598.2 days of age and 647.8 pounds in weight at the time of conception as compared to the heifers in Lot III which averaged 524 days of age and 550.5 pounds in weight. This older age and heavier weight of the heifers in Lot II offers an explanation for the difference between Lot II and III, but this does not explain the wide variation between Lots I and II in which the average age and weight at the time of conception are approximately the same. Therefore, this difference must be due to the rations and analysis of Table 14 shows that Lot II consumed 90.2 more pounds of total digestible nutrients per 100 pounds gain in weight than did Lot I. This indicates that the 50 percent hay ration fed Lot II is less efficient than the 25 percent hay ration fed Lot I for producing gains during the first gestation period.

Table 15. Feed and Weight Record of Heifers Fed Different Levels of Prairie Hay Plus a Vitamin A Supplement During the First Gestation Period

	: Lot IV	: Lot V	: Lot VI	: Lot VII
Level of hay intake	25%	50%	50%	Liberal
Number of animals	1	1	1	3
Ave. weight per animal:				
at conception, lbs.	554.0	646.0	568.0	545.7
at calving, lbs.	798.0	912.0	837.0	768.7
Gain, lbs.	244.0	266.0	269.0	223.0
Length of gestation in days	278.0	274.0	271.0	274.7
Daily gain, lbs.	.88	.97	.99	.81
Feeds consumed:				
Prairie hay, lbs.	872.1	1642.5	1198.4	2856.1
Beet pulp, lbs.	1857.7	1321.9	1338.7	442.8
Cottonseed meal, lbs.	710.4	763.2	795.0	909.4
Total lbs. T.D.N. per animal	2323.2	2327.4	2154.6	2355.4
Ave. lbs. T.D.N. consumed per 100 lbs. gain	952.1	875.0	801.0	1056.6

The heifers representing Lots IV, to VII inclusive (Table 15) received a vitamin A supplement during the entire gestation period. It may be noted that none of these lots equalled the expected gain of one pound daily although Lots V and VI approached it very closely. Lot IV made a smaller gain and this indicating effects of retard growth caused by the vitamin A deficiency which occurred during the first year of her life. Lot VII consisting of the three heifers fed the liberal hay ration, made the smallest daily gain of these four lots. This lot made smaller daily gains than Lot III (Table 14) which received a similar hay ration without the vitamin supplement. Therefore, these results indicate that

the addition of a vitamin A supplement to rations containing liberal amounts of prairie hay are of little or no value in producing larger gains in dairy heifers during the first gestation period.

Nutrient consumption by each of these four lots was nearly identical as can be noted in Table 15. Lot VI consumed the smallest total amount of feed and this was due to the fact that she seldom consumed the allotted amounts of hay offered.

In considering the efficiency of gain for these four lots it is noted that Lots V and VI which made the larger average daily gains also were more efficient in utilizing the total digestible nutrients consumed. Lots V and VI consumed 801.0 and 875.0 pounds of total digestible nutrients, respectively, per 100 pounds gain as compared to Lots IV and VII which consumed 952.1 and 1056.6 pounds per 100 pounds gain, respectively. The lower efficiency of Lot IV as compared with Lots V and VI is explained by the fact that she consumed approximately the same amount of nutrients during the gestation period but only gained 244 pounds in weight whereas Lots V and VI gained 266 and 269 pounds, respectively. Lot VII, receiving the liberal hay ration, was the least efficient of all four lots as it consumed the largest amount of nutrients and made the smallest total gain during the period. These results again indicate that a ration furnishing a large portion of its total digestible nutrients in the form of hay is less efficiently utilized than a ration furnishing a major portion of the nutrients in the form of concentrates.

Summary

This study is concerned with the growth and development of Jersey heifers fed different levels of prairie hay as the sole roughage from birth to the age of two years. Three levels of hay were fed. In the 100 percent, or standard hay ration the amount of hay fed at any given age was practically equal to the amounts consumed by Jersey heifers when hay was fed ad libitum. In the two restricted rations the daily hay allowances were limited to 25 and 50 percent of the amounts of hay fed in the 100 percent rations at corresponding ages. In addition to the hay, each ration included dried beet pulp and cottonseed meal in such amounts that the total digestible nutrients furnished by it met the nutrient requirements of dairy heifers for growth according to the Minnesota Standard (12). When prairie hay supplied adequate amounts of vitamin A heifers fed the 25, 50, and 100 percent hay rations made gains in weight and height during the period from birth to the age of two years which compare very favorably with the Missouri standards (25). At the age of two years the heifers fed the 25, 50, and 100 percent hay rations on the average, weighed 793, 760 and 718 pounds, respectively, as compared with the Missouri normal of 733 pounds.

Average gains in height at withers of the heifers fed these three levels of prairie hay were very uniform and satisfactory during the period from birth to two years of age. None of the three lots of heifers was ever below 93.0 percent of normal height at any time during the two year period. At the age of two years they measured 118.8, 117.6, and 177.7 centimeters, respectively, as compared with the Missouri normal of 119.1 centimeters.

From birth to the age of two years, the heifers fed the 25, 50, and 100 percent hay rations respectively consumed 594.1, 619.8, and 663.5

pounds of total digestible nutrients per 100 pounds gain as compared to the normal requirements of 682.2 pounds.

On the average, heifers fed the 25, 50, and 100 percent hay rations consumed 1298.8, 2442.9, and 4194.9 pounds of prairie hay per animal, respectively, during the period from birth to two years of age.

Three heifers, designated as lots IV, V, and VI in this study, developed symptoms of vitamin A deficiency during the period from birth to six month of age, when fed limited rations of poor quality prairie hay.

The amounts of vitamin A present in the limited allowances of this low grade hay consumed by three young heifers was inadequate for normal growth. Each of three heifers showed a marked decline in the rate of gain, became physically abnormal, and two of them developed a permanent type of blindness due to the constriction of the optic foramen. Addition of a vitamin A supplement to the ration in the form of 10 cc. of Puratene daily, stimulated growth in these heifers, and corrected the abnormal condition of the eyes of one heifer which had not become permanently blind.

At the age of two years Lot IV, weighed 657 pounds and during the two years consumed 708.8 pounds of total digestible nutrients for each 100 pounds gain in weight. Lot I, in which the heifers developed normally on the same level of hay intake, weighed 793 pounds at this age and consumed 594.1 pounds of total digestible nutrients per 100 pounds gain in weight. Lots V and VI fed the 50 percent hay ration weighed 717 and 639 pounds respectively, at two years of age. They consumed 668.8 and 621.5 pounds of total digestible nutrients respectively, per 100 pounds gain as compared with Lot II, in which the heifers developed in a normal

manner on the 50 percent hay ration, and weighed 760 pounds at two years of age. They consumed 619.8 pounds of total digestible nutrients per 100 pounds gain in weight.

No beneficial effect on growth was noted as the result of the addition of a vitamin A supplement to the rations of three heifers fed liberal quantities of prairie hay. Heifers fed this ration showed no increase in rate of gain when compared with another heifer of similar age which received the same hay ration without the vitamin A supplement. These results indicate that under the conditions of this experiment rations consisting of liberal quantities of prairie hay furnished adequate amounts of vitamin A to produce normal growth in dairy heifers to the age of two years.

During the first gestation period heifers fed the 25, 50, and 100 percent hay rations made average daily gains of 1.11, 1.02 and .95 pounds respectively. Feed allowances during this period were based on a feeding schedule which would produce an estimated gain of one pound daily. The results obtained show that all three rations were adequate for this purpose. The gains made by the heifers fed the 25 and 50 percent hay rations were slightly larger than the gains made by the heifers fed the 100 percent hay ration. However, due to the limited number of animals in all three lots these differences cannot be considered very significant.

Conclusions

Since this is only a preliminary report of an investigation which will be continued for several years, final conclusions should not be drawn from the limited records which are now available. However, the results obtained for the twenty-seven animals available in this study do permit the statement of several tentative conclusions:

1. Limited prairie hay rations containing 25 and 50 percent of normal hay allowances, properly supplemented with sufficient amounts of concentrates were equally as satisfactory as the 100 percent prairie hay ration in producing normal growth and development of Jersey heifers during the period from birth to two years of age provided the hay furnished adequate amounts of vitamin A.

2. The commercial vitamin A supplement, Puratene, corrected to a marked degree, the symptoms of vitamin A deficiency which developed in young dairy heifers as a result of feeding rations containing limited amounts of poor quality prairie hay.

3. No beneficial effect on growth was noted as the result of the addition of a vitamin A supplement to the ration of heifers fed liberal quantities of prairie hay.

4. All three levels of hay intake, namely, the 25, 50, and 100 percent hay rations were satisfactory for producing the gains desired during the first gestation period.

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