EXPERIMENTAL RATIONS TO STUDY THE PHOSPHORUS REQUIREMENT OF YOUNG DAIRY BULLS FOR GROWTH AND REPRODUCTION

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INTRODUCTION

Reduced fertility or infertility in dairy cattle is a problem of utmost concern to dairymen, artificial breeding associations, and research workers.

In approaching the problem from a nutritional standpoint, the mineral which has been associated most commonly with reduced fertility in cows seems to be phosphorus.

It is not an uncommon practice to keep dairy bulls on poorly managed pasture or in exercise pens.

If the bulls are fed a simple grain mixture, or no grain at all, and a low quality roughage, it is possible that the level of phosphorus intake may be quite low.

This problem was undertaken to establish the relationship between phosphorus intake and its effect upon semen production and quality, and body development.

The problem of devising an experimental ration for a controlled phosphorus study with ruminants was difficult, since the roughages usually fed vary considerably in their phosphorus content.

This study conducted at Oklahoma A. and M. College has been concerned primarily with the experimental ration phase.

REVIEW OF LITERATURE

The relationship of mineral intake to fertility in animals has received considerable attention. Mineral deficiencies in rations for cows have been shown to produce reproductive failures (16, 36, 38, 54, 62, 63).

Variations found in the phosphorus content of the ingredients of experimental rations have been recognized as a factor affecting the accuracy of phosphorus studies (11, 18, 34, 36). The practical approach has been the use of a concentrate that was as low in phosphorus content as possible and hay that was grown on a phosphorus deficient soil (6, 76).

Wood pulp or cellulose, low in phosphorus content, has been successfully fed to ruminants for many years as a hay replacement (1, 4, 5, 7, 12, 15, 19, 20, 37, 39, 41, 42, 43, 45, 47, 50, 53, 55, 56, 57, 60, 67, 78, 79, 81, 83).

Commonly used high protein concentrates are relatively high in phosphorus content. Blood fibrin, a concentrate very high in protein and relatively low in phosphorus, has been successfully used in ruminant rations (33, 38, 62). Ground polished rice, a low phosphorus cereal, has been used to obtain a low phosphorus concentrate (31, 34, 62).

The amount of phosphorus needed by young growing dairy cattle has been set forth by several authorities (2, 6, 28,

29, 30, 34, 36, 40, 44, 46, 51, 52, 54, 61, 72, 73, 74, 76, 77, 80). The National Research Council subcommittee on Nutrition of Dairy Cattle has summarized these recommendations in their report (64).

Criteria used in the evaluation of phosphorus deficiencies have been the reduction of the inorganic phosphorus level of the blood (3, 12, 16, 18, 32, 35, 36, 54, 63, 65, 66, 69, 75, 82) and the occurrence of rickets (8, 9, 17, 21, 24, 26, 46, 49, 54, 57, 68, 70, 76).

Numerous types of metabolism stalls designed for digestion and balance trials have been reported (10, 23, 25, 71).

There have been no reports in the literature on the problem of phosphorus deficiency, sexual development, and semen production in the young growing dairy bull.

EXPERIMENTAL PROCEDURE

Two groups of bull calves were used to study the utilization of two experimental concentrates formulated to control level of phosphorus intake. These concentrates, Table 1, were calculated to supply protein and T.D.N. recommendations of the N.R.C. (64) for young dairy cattle. It was the specific objective of the work reported here to determine the growth and sexual development of young dairy bulls on these concentrates for extended periods of time.

General Procedure

Prior to placing these bulls on the experimental concentrate they were reared to an age range of four to six months on conventional type rations, Tables 2 and 3. Group I bull calves, consisting of three Holsteins and two Guernseys, were individually fed: (a) milk at a rate of 100 pounds per hundred weight per day until an average of 400 pounds were consumed; (b) calf starter ad libitum up to a maximum of 4 pounds per day; and (c) alfalfa hay ad libitum. Group II bull calves, consisting of six Ayrshires, were individually fed: (a) milk at the rate of 8, 9, 10, 9, 7, 6, 4, and 0 pounds per day for weeks 1 to 8, respectively; (b) calf starter ad libitum up to a maximum of 4 pounds per day; and (c) prairie hay ad libitum.

Table 1

Percentage composition of feeds as analyzed

Ingredient	% of Conc. I	% of Conc. II	Dry matter	Ash	Organic matter	Ca	P	Fiber	N.F.	P	NTE
Corn	15.0	15.0	91.62	1.40	90.22	0.01	0.25	1.57	2.27	1.420	77.50
Hominy	30.0	--	92.60	2.61	89.99	0.04	0.446	7.33	5.84	1.640	66.57
Oats	10.0	9.0	93.35	3.83	89.52	0.10	0.037	9.37	3.52	2.190	65.15
Beet pulp	15.5	20.5	92.27	3.41	88.86	0.83	0.63	21.50	0	1.200	59.66
Fibrin	10.0	12.0	92.18	3.15	89.03	0.36	0.114	0	0.21	14.290	0
Wood pulp	1.5	1.5	97.55	0.16	97.39	0.07	0.06	77.33	0.13	0.50	16.64
Omalass	15.0	15.0	91.64	6.87	84.77	0.40	0.053	4.82	3.20	1.750	59.60
Molasses	--	--	78.55	7.27	71.28	0.62	0.020	0	0.210	0.590	60.32
Salt	1.0	1.0	100.00	99.76	--	0.24	0.063	0	0	0.030	0
Bone meal	1.0	--	97.81	76.61	21.20	28.00	12.400	0	6.29	1.750	2.36
Limestone	1.0	1.0	100.00	99.82	--	38.13	0.017	0	0	0.025	0
Polished rice	--	25.0	89.27	0.63	88.64	0.07	0.115	0.20	0.45	1.060	81.79
% composition of Conc. I			92.1	6.02	86.08	0.87	0.31	7.96	3.25	2.86	60.56
% composition of Conc. II			91.0	5.01	85.99	0.66	0.11	6.56	1.88	2.67	63.41
Wood pulp - (40% wood pulp molasses mix. 60% molasses)			86.2	4.42	81.73	0.40	0.054	30.9	0.183	0.56	47.23

Quadrex added to: Concentrate I 8/4/53 - 2/1/54 - 27.2 gm/100 lb.
2/1/54 - 5/1/54 - 76 gm/100 lb.

Concentrate II 1/16/54 - 2/1/54 - 27.2 gm/100 lb.
2/ 1/54 - 5/1/54 - 114 gm/100 lb.

Aureomycin Hcl added to both concentrates 2 gm/100 lb.

Table 2

Concentrate fed Group I prior to August 5, 1953

Ingredient	(lb.)
Cracked corn	550
Wheat bran	200
Rolled oats	500
Cottonseed meal (41%)	400
Alfalfa leaf meal	100
Dried buttermilk	100
Omalass	150
Iodized salt	10
Steamed bone meal	20
Total	2030
Roughage	
Prairie hay	ad libitum

Milk offered at rate of 1#/10# body weight to total 400 lb.

Table 3

Concentrate fed Group II prior to January 17, 1954

Ingredient	(lb.)
Starter	
Cracked Corn	550
Wheat bran	200
Rolled oats	500
Cottonseed meal	400
Alfalfa leaf meal	100
Dried buttermilk	100
Omalass	115
Iodized salt	15
Calcium	15
Steamed bone meal	15
Total	2010
Roughage	
Alfalfa hay	ad libitum

Milk offered: 371 lb. per calf.

It was the purpose of Concentrate I, Table 1, to develop a complete ration with the exception of phosphorus. The level of phosphorus intake was calculated to be approximately two-thirds of the N.R.C. recommended allowance for young growing dairy cattle. Concentrate II was calculated to contain 25 to 30 per cent of the same N.R.C. recommendations.

The experimental concentrates differed only in the composition of the respective concentrates. Group I was first offered Concentrate I at the average age of 5.25 months while Group II bull calves were first offered Concentrate II at the average age of 4 months. Both concentrates were offered according to the feeding schedule, as presented in Table 4. Both concentrate mixtures were made up and mixed by the author in a home-made batch mixer. Cracked shelled corn and crushed oats were used to give a coarse texture to the starter. The polished rice was ground before including it in the mixture. Fibrin, as listed in Table 1, was ground dried beef blood fibrin.[1] The wood pulp (Solka Floc)[2] was used to give fiber and bulk to the ration. A commercial preparation, Quadrex,[3] was added according to the

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[1]Purchased from Adhesive Division, Armour and Co., 1355 West 31st St., Chicago 9, Illinois.

[2]Solka-Floc-BW-20 (Nov. 1161) was purchased from Brown Co., 110 S. Dearborn, Chicago 3, Illinois.

[3]Nopco Chemical Co., Inc. Vitamin Products Laboratory contributed the Quadrex "10" used.

guaranteed analysis of the product for vitamins A and D. Aureomycin Hcl[4] concentrate was included in the ration as a precautionary therapeutic measure.

Table 4

Calculated feeding schedule for
Group I and Group II

Body weight (lb.)	Concentrate I & II (lb.)	Pulp-molasses mixture (lb.)	Beet pulp
150	4.0		
200	4.6	1.4	1.0
300	5.3	3.2	1.0
400	5.5	4.5	1.0
500	5.7	6.3	1.0
600	5.8	8.2	1.0
700	6.0	10.0	1.0
800	6.2	11.8	1.0
900	6.4	13.0	1.0
1000	6.5	15.5	1.0

The wood pulp-blackstrap molasses "roughage" was hand mixed in an open mixing trough with hoe or shovel and then run through a modified, motor driven beet chopper to achieve greater uniformity.

Semen production was utilized as the means of assessing sexual development. Total volume, motility rate, per cent of motile sperm, per cent abnormal, total sperm number, pH, and days of observed motility in egg yolk three per cent

[4]Lederle Laboratories, Pearl River, New York, contributed the 89 per cent pure aureomycin used in this experiment.

citrate sulfanilimide at a 1:10 dilution rate were used to evaluate the quality of semen produced.

X-rays were taken of the right metacarpal bone to examine bone formation.

Samples of the individual feed ingredients of both concentrate mixtures and the roughage were taken for proximate analyses.[5] Also, the mixtures of concentrate and roughage were sampled as fed for similar analyses.

Except for collection periods in metabolism stalls, all calves were kept in individual tie stalls that were equipped with hay manger and grain box, grain bucket and water bucket.

When possible, body weight, heart girth, and height at withers data were obtained at weekly intervals. Also, consumption of feed was recorded for the same intervals. Blood samples were taken periodically two and one-half to three hours after feeding and the plasma was analyzed for inorganic phosphorus (22) and calcium (13).

Digestion Trial Procedure

Two digestion trials were conducted with each group to determine: (a) the apparent digestibility of the ration, and (b) calcium, phosphorus, and nitrogen balances. All calves were placed in the metabolism stalls for a ten day preliminary period prior to the collection period with the

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[5] Association of Official Agricultural Chemists, Official Methods of Analyses, 7th ed., Washington, D.C., 1950.

exception of trial I which had a three day preliminary period. A wire grid and galvanised iron urine funnel in the stall floor were substituted for the conventional rubber urine funnel. Feces were collected in galvanized iron trays held at floor level. Urine and fecal samples were collected separately at 24 hour intervals and stored in two-quart screw cap jars at about 37 degrees Fahrenheit. The urine was diluted with tap water to the constant weight of 10 KG in trial II and III and 5 or 8 KG in trial IV. A 1.5 per cent sample of urine was taken. In trial I ten per cent of the total daily urine was taken as the sample. A preservative, consisting of 10 ml. of a 1:1 H_2SO_4 solution, was used in all urine sample jars. The daily fecal collection was weighed, thoroughly mixed, and a five per cent sample taken.

During the time when the bulls were in the collection stalls, feed and water were offered twice daily. All refused concentrate and roughage was bulked for each collection period and analyzed for each calf as a single sample. Blood samples were taken from all calves at the start and close of each collection period for plasma inorganic phosphorus and calcium analyses (13 and 22). Feeds as offered, weigh backs, and feces were analyzed for dry matter, ash, crude fiber, ether extract, calcium, phosphorus, and nitrogen according to A.O.A.C. procedures.[6] Urine was analyzed for calcium, phosphorus, and nitrogen.[6]

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[6]See footnote 5, page 9.

The fecal dry matter was determined by drying a 200 gram sample in an oven for 12 hours. The sample was then ground in a Wiley mill, sampled, and stored in a screw cap glass jar. The dried samples were dried again in trials I and II to determine the absorbed moisture. For trials III and IV it was assumed that the sample was moisture free after the first drying.

RESULTS AND DISCUSSION

The effectiveness of the experimental rations in achieving the objective was measured by: (a) digestion trial data; (b) blood plasma and semen data; (c) growth and body weight change; and (d) the general acceptance of the ration by the experimental animals.

Digestion Trial Data

Detailed data for digestion trials I, II, III, and IV are presented in Appendix Tables I to IX inclusive. Group I bulls were involved with trials I and II. Table 5 summarizes the data of trial I. During trial I number 3 lost 25 pounds of body weight and had, also, the lowest retention of nitrogen, phosphorus, and calcium. The bull with the most nearly normal body weight for his age, number 4, had the highest retention of nitrogen and calcium. It was of interest to note that the range of phosphorus excreted in the urine was greater than for calcium, Table 5. There was no apparent relationship between the per cent of phosphorus and calcium excreted in the urine and corresponding retention values. Nitrogen, phosphorus, and calcium retentions were positive in all cases in this trial; however, there was considerable individual variation in the per cent retained in each case. The average per cent apparent digestibility of

dry matter, organic matter, ether extract, crude fiber, and nitrogen was slightly lower than expected on the basis of digestion coefficients published by Morrison (62) for similar feeds. These apparent discrepancies might have been a result of differences in the age and class of the animals used to obtain apparent digestibilities. Among other factors involved might be the physical character of the ration and lack of published digestion coefficients for some of the specific feed ingredients used.

Table 5

Summary of data for digestion trial I

Calf	No. 3	No. 4	No. 11	No. 15	No. 21
Per cent digested					
Dry matter	66.8	71.6	79.1	74.2	65.0
Organic matter	67.3	71.7	79.7	74.8	65.5
Ether extract	21.8	64.4	61.3	39.7	47.4
Fiber	34.8	43.6	61.8	52.5	28.2
Nitrogen	66.0	71.5	75.7	73.2	63.8
Per cent retained					
Nitrogen	12.5	42.3	31.9	32.5	26.6
Phosphorus	31.0	76.0	82.3	76.5	53.5
Calcium	14.8	47.7	47.2	38.1	28.5
Ret./cwt./day (gm.)					
Nitrogen	2.3	8.7	6.2	7.6	6.4
Phosphorus	0.8	1.9	2.0	2.2	1.4
Calcium	0.9	3.7	3.1	3.1	2.1
Per cent excreted in urine					
Nitrogen	61.09	50.72	64.26	60.27	50.80
Phosphorus	42.37	5.88	17.27	1.12	43.41
Calcium	4.35	4.00	2.08	2.24	1.14

Data for digestion trial II are summarized in Table 6. The apparent digestibilities of dry matter, organic matter, crude fiber, and nitrogen were very similar to those obtained in trial I while that for ether extract was considerably higher.

Table 6

Summary of data for digestion trial II

Calf	No. 3	No. 4	No. 11	No. 15	No. 21
Per cent digested					
Dry matter	64.5	67.0	75.8	72.3	77.4
Organic matter	64.7	67.0	75.8	72.8	77.5
Ether extract	50.4	75.8	60.9	70.7	66.5
Fiber	11.2	36.6	54.4	48.1	57.6
Nitrogen	67.5	65.3	82.8	67.4	75.8
Per cent retained					
Nitrogen	42.0	41.4	58.6	41.7	52.9
Phosphorus	53.4	61.0	48.9	53.0	63.4
Calcium	29.5	57.6	46.7	32.6	53.2
Ret./cwt./day (gm.)					
Nitrogen	9.9	7.1	14.3	10.1	11.0
Phosphorus	1.7	1.5	1.3	1.9	1.9
Calcium	2.3	2.7	3.4	3.1	4.6
Per cent excreted in urine					
Nitrogen	93.85	40.00	68.79	44.05	48.66
Phosphorus	21.14	8.86	6.18	22.75	26.82
Calcium	4.51	7.68	5.91	3.12	7.73

The per cent retention of nitrogen and calcium was higher for trial II than for trial I. This may be accounted for at least partially by the fact that there was no weight loss by the bulls while in the digestion stalls the second time.

Retention of phosphorus per hundred weight per day was the same in trial I and trial II. Here again, the percentage of total excreted phosphorus in the urine was much more variable than calcium. During trial II, number 11 went off feed, refused a total of 25.9 pounds of his ration, and was not able to stand in the digestion stall on the last collection day. Consequently, he was removed one-half day early.

Group II bulls responded to ration II in a satisfactory manner. Digestion trials III and IV were conducted with this group. These data are presented in Tables 7 and 8.

Table 7

Summary of data for digestion trial III

Calf	No. 33	No. 34	No. 35	No. 36	No. 37	No. 38
Per cent digested						
Dry matter	78.5	78.8	83.6	77.9	79.4	73.8
Organic matter	78.9	79.2	84.0	78.4	80.0	74.3
Ether extract	57.1	49.1	73.0	47.5	38.5	56.8
Fiber	52.9	52.8	68.9	44.0	47.7	45.4
Nitrogen	70.7	71.3	65.6	67.6	75.9	68.1
Per cent retained						
Nitrogen	27.9	30.2	-35.4	22.2	27.0	23.3
Phosphorus	44.0	40.6	43.9	40.0	41.6	35.7
Calcium	49.7	50.0	59.7	42.9	40.3	30.5
Ret./cwt./day (gm.)						
Nitrogen	4.9	6.2	- 2.9	4.1	6.4	5.2
Phosphorus	0.6	0.7	0.4	0.6	0.7	0.5
Calcium	3.4	3.8	2.8	3.2	3.2	3.0
Per cent excreted in urine						
Nitrogen	59.36	58.80	74.55	40.69	67.01	58.42
Phosphorus	2.44	1.48	1.94	1.06	0.44	0.81
Calcium	13.87	26.83	30.00	31.47	20.14	15.59

Table 8

Summary of data for digestion trial IV

Calf	No. 33	No. 34	No. 35	No. 36	No. 37	No. 38
Per cent digested						
Dry matter	73.3	86.7	86.7	81.6	79.8	83.7
Organic matter	74.1	87.5	88.7	82.7	80.8	84.5
Ether extract	76.5	85.4	80.6	90.0	63.0	76.0
Fiber	35.0	76.6	75.8	71.0	62.1	72.8
Nitrogen	69.5	78.8	83.8	66.0	78.7	80.6
Per cent retained						
Nitrogen	25.5	31.7	31.3	90.8	34.6	39.6
Phosphorus	53.0	71.4	52.0	34.5	49.1	49.1
Calcium	19.0	29.3	37.3	15.6	22.1	29.5
Ret./cut./day (gm.)						
Nitrogen	4.3	5.1	5.3	1.0	6.3	7.7
Phosphorus	0.6	0.8	0.5	0.03	0.5	0.5
Calcium	0.9	1.3	1.6	0.6	1.1	1.4
Per cent excreted in urine						
Nitrogen	59.09	68.91	76.47	62.56	69.67	71.07
Phosphorus	3.38	3.90	1.74	1.50	1.38	2.03
Calcium	5.96	45.08	26.53	17.99	17.94	15.33

The apparent digestibility of this ration was slightly higher than ration I. These apparent digestibilities were obtained with animals that were not consuming as much of the food offered them as were the animals in digestion trials I and II. The same situation existed in trial IV. Since Group II animals did not remain on full feed in either trial III or IV, they might have been more efficient in utilizing material in the digestive tract than were Group I animals.

Variation in individual feed consumption and consequent digestion trial results may be attributed in part to the

fact that, as the number of days in the digestion stalls increased, the general condition of the bulls declined. Number 35 refused a total of 34 pounds of feed during the collection period in trial III. This bull had the lowest nitrogen, phosphorus, and calcium retentions per hundred weight per day. In terms of per cent of intake retained, however, this bull had comparatively high retention values.

All values in trial IV were positive. With the exception of calcium retention and urinary calcium excretion values, the apparent digestibilities, retention, and urinary excretion values were slightly higher in trial IV than in trial III. It is important to note that bulls of Group II excreted a higher per cent of urinary calcium than urinary phosphorus. This situation was reversed with respect to bulls of Group I in trials I and II. Actually, bulls in trials III and IV excreted more urinary calcium than did bulls in trials I and II. Very little urinary phosphorus was excreted in trials III and IV, indicating that the bulls were able to reduce urinary excretion loss when intake was severely limited.

A comparative summary of all digestion trials is presented in Tables 9 to 14. These data were assembled to permit ready appraisal of performance during the four trials.

Table 9

Average nitrogen data from digestion trials

Trial number	I	II	III	IV
Intake (gm.)	611.6	811.3	416.3	397.5
Outgo: feces (gm.)	183.2	231.3	123.8	90.1
urine (gm.)	238.2	217.9	189.5	186.3
Per cent digested	70.0	71.7	69.9	76.2
Per cent retained	29.2	47.3	15.9	42.3
Bal./day (gm.)	17.7	38.2	9.2	12.1
Ret./cwt./day (gm.)	6.2	10.5	4.0	5.0

Table 10

Average calcium data from digestion trials

Trial number	I	II	III	IV
Intake (gm.)	213.2	307.8	158.1	109.7
Outgo: feces (gm.)	129.6	171.7	67.1	67.2
urine (gm.)	4.0	10.5	18.7	14.6
Per cent retained	35.3	43.9	46.9	25.5
Bal./day (gm.)	7.2	12.2	7.2	2.8
Ret./cwt./day (gm.)	2.6	3.2	3.2	1.2

Table 11

Average phosphorus data from digestion trials

Trial number	I	II	III	IV
Intake (gm.)	75.8	111.4	32.8	26.3
Outgo: feces (gm.)	18.8	34.9	19.3	12.5
urine (gm.)	7.3	12.7	0.3	0.3
Per cent retained	63.9	55.9	41.0	51.5
Bal./day (gm.)	4.6	6.3	1.3	1.3
Ret./cwt./day (gm.)	1.7	1.7	0.6	0.5

Table 12

Average dry matter data from digestion trials

Trial number	I	II	III	IV
Intake (gm.)	27495	38629	20772	18634
Outgo (gm.)	7929	11074	4538	3441
Per cent digested	71.4	71.4	78.7	82.0

Table 13

Average crude fiber data from digestion trials

Trial number	I	II	III	IV
Intake (gm.)	5021	8122	3735	3290
Outgo (gm.)	2842	4604	1752	1100
Per cent digested	44.7	41.6	53.5	65.6

Table 14

Average digestibility of other extract

Trial number	I	II	III	IV
Intake (gm.)	386	673	326	434
Outgo (gm.)	194	227	151	93
Per cent digested	46.9	64.9	53.7	78.6

The ratio of calcium to phosphorus was determined for digestion trials for the following: (a) total intake; (b) total excretion; and (c) retention. These data are presented in Tables 15, 16, and 17. The ratio of calcium to phosphorus retained by all calves in all trials was essentially the same with the exception of trial III. This was

true despite slightly varying ratios of calcium to phosphorus ingested and more widely varying ratios in the excreta.

Table 15

Ratio of calcium to phosphorus for Group I

Digestion trial no.	No.	Total Intake	Total Outgo	Retention
I	3	2.46:1	3.03:1	1.18:1
	4	3.08:1	6.70:1	1.94:1
	11	2.65:1	7.85:1	1.52:1
	15	2.76:1	7.26:1	1.37:1
	21	2.88:1	4.43:1	1.53:1
II	3	2.46:1	3.67:1	1.54:1
	4	3.02:1	4.91:1	1.81:1
	11	2.69:1	2.79:1	2.58:1
	15	2.69:1	3.85:1	1.66:1
	21	2.84:1	3.64:1	1.38:1

Table 16

Ratio of calcium to phosphorus for Group II

Digestion trial no.	No.	Total Intake	Total Outgo	Retention
III	33	4.71:1	4.22:1	5.34:1
	34	4.72:1	3.96:1	5.83:1
	35	5.39:1	3.88:1	7.31:1
	36	4.64:1	4.44:1	4.95:1
	37	4.82:1	4.92:1	4.68:1
	38	4.86:1	4.17:1	5.41:1
IV	33	4.20:1	7.25:1	1.50:1
	34	3.86:1	8.61:1	1.64:1
	35	4.25:1	5.54:1	3.05:1
	36	3.39:1	5.02:1	1.76:1
	37	4.42:1	6.77:1	1.99:1
	38	4.34:1	5.97:1	2.62:1

Table 17

Ratio of calcium to phosphorus: average results of each digestion trial

Concentrate no.	Trial no.	Total Intake	Total Outgo	Retention
I	I	2.81:1	5.12:1	1.60:1
	II	2.76:1	3.85:1	1.97:1
II	III	4.82:1	4.38:1	5.44:1
	IV	4.17:1	6.39:1	2.06:1

Group I bulls had an average consumption of 68.8 per cent of the N.R.C. recommended allowance for phosphorus and 217.1 per cent of the N.R.C. recommended allowance for calcium as compared to 18.3 per cent and 90.1 per cent, respectively, for bulls of Group II. Since Group I bulls were consuming all of the feed that was offered them, the above values represent intended consumption for those animals. The difference between the intended consumption and actual consumption is due to the difference between estimated calcium and phosphorus composition and the respective analyzed values. Group II bulls would have consumed approximately 126.5 per cent of the calcium allowance and 34.9 per cent of the phosphorus allowance recommended by N.R.C. if they had consumed all the feed offered them.

Blood Plasma and Semen Data

The data presented in Tables 18 and 19 show blood plasma calcium and inorganic phosphorus values, respectively.

Table 18

Blood plasma inorganic phosphorus of calves (mg %)

Group I date	No. 3	No. 4	No. 11	No. 15	No. 21
9/11/53	8.28	8.96	8.88	9.52	7.08
9/22/53	5.76	--	8.28	9.48	8.96
10/26/53	9.32	7.08	10.80	9.68	9.04
11/21/53	7.76	7.88	8.60	9.04	9.16
12/ 9/53	8.80	10.32	8.10	9.02	10.00
12/19/53	8.92	8.80	7.32	8.96	9.08
1/30/54	5.04	7.76	6.56	6.52	8.00
2/13/54	8.88	8.16	9.20	9.96	7.40
2/27/54	6.84	8.68	7.48	8.04	5.36
3/ 6/54	7.40	8.80	10.36	7.68	9.80
3/13/54	9.96	9.48	12.00	10.56	9.52
3/27/54	9.68	8.72	10.52	9.32	10.36
4/10/54	8.92	7.92	9.96	8.16	8.80
4/17/54	9.52	9.48	10.36	7.84	11.00
5/ 1/54	7.48	10.12	11.72	10.84	11.00
6/ 6/54	7.68	7.28	7.32	7.68	9.88

Group II date	No. 33	No. 34	No. 35	No. 36	No. 37	No. 38
1/16/54	6.68	7.76	8.80	8.60	8.52	10.08
1/22/54	5.68	5.52	3.60	5.24	4.52	6.44
1/30/54	4.60	4.48	4.68	4.28	3.48	5.16
2/16/54	5.36	5.36	6.36	6.24	5.00	6.80
2/27/54	6.20	5.68	5.80	5.12	4.80	6.48
3/ 6/54	5.92	5.36	4.68	4.92	5.16	6.12
3/13/54	6.24	4.32	6.36	4.48	4.72	5.68
3/20/54	7.52	2.48	6.56	1.84*	6.72	6.92
3/27/54	6.20	4.40	6.60	4.92	4.04*	6.36
4/ 5/54	7.60	6.04	6.84	3.68	5.68	7.00
4/15/54	7.40	5.68	7.16	6.16	6.00	6.72
5/ 1/54	5.68	5.08	8.04	6.56	8.92	7.16
6/ 6/54	5.20	3.40	5.04	3.72	4.64	5.52

* Tubes containing these samples had very little plasma in them.

Table 19

Blood plasma calcium values (mg %)

Group I date	No. 3	No. 4	No. 11	No. 15	No. 21
9/11/53	10.5	11.3	11.2	8.0	12.0
9/22/53	9.3	10.0	9.2	10.6	10.6
10/26/54	9.4	11.2	10.5	10.3	11.1
11/21/53	9.9	9.9	10.9	9.7	10.4
12/ 9/53	10.0	10.6	12.2	10.3	11.9
12/19/53	10.8	11.2	10.6	12.3	11.7
1/30/54	11.0	9.1	9.8	10.4	9.8
2/13/54	11.3	11.3	11.7	11.6	11.7
2/27/54	7.9	11.6	10.1	11.7	7.0
3/ 6/54	10.2	12.0	11.6	11.6	10.1
3/13/54	11.4	11.9	11.1	10.1	11.4
3/27/54	10.1	10.2	11.6	11.0	10.6
4/10/54	12.1	9.4	10.5	9.3	9.6
4/17/54	10.8	10.5	11.1	11.2	11.6
5/ 1/54	11.1	11.3	9.6	10.5	10.4
6/ 6/54	8.6	9.4	9.2	8.7	10.3

Group II date	No. 33	No. 34	No. 35	No. 36	No. 37	No. 38
1/16/54	8.70	9.7	9.2	9.9	10.1	9.3
1/23/54	10.3	10.5	8.6	10.6	9.0	9.3
1/30/54	9.1	10.9	10.9	10.3	10.6	10.4
2/16/54	11.5	10.7	11.6	11.3	11.3	10.6
2/27/54	10.1	13.0	11.0	12.1	11.6	11.9
3/ 6/54	10.3	12.1	11.1	11.6	11.7	9.9
3/13/54	10.9	11.0	12.0	11.4	11.0	11.6
3/20/54	11.5	6.7	10.1	--	10.3	9.0
3/27/54	9.6	8.6	12.4	11.0	--	11.7
4/ 5/54	11.8	12.2	10.8	8.4	11.6	10.1
4/15/54	10.0	11.0	11.3	10.5	11.7	9.7
5/ 1/54	12.5	13.5	11.4	11.9	12.6	9.6
6/ 6/54	10.6	10.0	9.9	9.7	9.6	11.1

Two samples were lost in the process of plasma calcium analyses, and one was lost in phosphorus analysis. Plasma calcium values were essentially equal in both groups for the values reported here and were in the normal reported range for young dairy bulls (16, 63). Plasma inorganic phosphorus values for bulls in Group I were normal (16, 63), but Group II bulls showed inorganic phosphorus values that were approximately 3 milligrams per cent lower than those of Group I.

Only bulls of Group I were producing semen during the time data reported here were taken. Number 11 showed no desire whatsoever to mount and serve an artificial vagina. This condition was attributed primarily to injuries to his forelegs while in the digestion stalls the second time. All other bulls in Group I showed normal sexual development. Sexual interest became apparent at an average age of 7.6 months. By the average age of 9.3 months they were able to serve the artificial vagina, but they were not capable of producing a true ejaculate until an average age of 11.3 months. Data describing the semen collected is presented in Table 20. The semen produced was not as high in quality as that from mature bulls, but it compared very favorably with semen from other bulls of similar age (16, 63).

Growth and Body Weight Change

Complete individual bull data are presented in Appendix Tables X to XXI inclusive.

Table 20

Semen data for Group I bulls

Bull no.	Date	Ejaculate no.	Vol. (cc)	Motility %	Motility rate	Per cent abnormal	pH	Million sperm/ml.	Storage length (days)
3	2/22/54	1	2.3	5	1	20	7.35	150	1
	3/11/54	1	5.0	70	3	30	6.98	200	11
	3/18/54	1	2.5	60	3	20	6.80	285	12
	3/25/54	1	4.0	50	3	20	7.20	175	10
	4/ 4/54	1	2.0	0	0	20	6.80	190	0
	4/ 9/54	1	2.4	70	3	40	6.92	150	17
	5/ 4/54	1	2.7	10	1	20	6.70	575	6
	5/ 4/54	2	2.3	40	2	20	6.70	470	16
	5/11/54	1	3.0	70	4	1	6.60	490	19
4	1/ 6/54	1	4.0	10	1	10	7.2	--	2
	1/13/54	1	2.2	10	1	15	7.2	--	2
	1/27/54	1	3.6	20	2	10	6.95	--	3
	2/ 5/54	1	3.5	60	3	20	6.75	--	5
	2/12/54	1	4.0	30	1	20	7.00	--	2
	2/22/54	1	6.5	30	2	20	6.80	1160	4
	3/ 3/54	1	5.0	70	2	20	6.92	1490	5
	3/11/54	1	6.0	70	3	40	7.20	1590	13
	3/19/54	1	3.2	70	3	10	6.82	1650	10
	3/25/54	1	5.6	70	3	10	6.8	1120	8
	4/ 6/54	1	2.3	60	2	20	6.5	820	13
	4/ 9/54	1	2.0	40	2	10	6.86	1000	9
	4/ 9/54	2	3.3	40	2	20	6.90	2000	19
	4/20/54	1	2.0	60	4			2160	25
	5/ 4/54	1	4.6	50	2	20	6.55	1280	22
	5/ 4/54	2	4.8	70	3	20	6.55	740	23
	5/11/54	1	8.0	80	4	1	6.42	940	28

Table 20 (Continued)

Bull no.	Date	Ejaculate no.	Vol. (cc)	Motility %	Motility rate	Per cent abnormal	pH	Million sperm/ml.	Storage length (days)
11	Unable to mount and thrust								
15	2/22/54	1	2.4	5	1	10	7.10	1620	1
	3/11/54	1	4.5	80	3	20	6.82	1790	17
	3/19/54	1	1.5	0	0	0	7.05		
	3/19/54	2	2.3	60	3	40	7.30	1235	21
	3/25/54	1	6.4	80	3	20	6.80	690	7
	4/ 6/54	1	2.9	60	2	10	6.60	725	22
	4/9/54	1	2.2	50	3	10	6.90	740	34
	4/21/54								10
	5/ 4/54	1	4.0	50	3	20	6.50	119	28
	5/ 4/54	2	4.0	60	1	20	6.50	132	8
	5/11/54	1	2.4	95	4		6.68	1600	27
21	3/25/54	1	3.5	60	3	20	6.90	450	14
	4/ 6/54	1	3.5	90	3	10	6.35	840	23
	4/9/54	1	2.0	60	3	25	6.82	1980	25
	3/19/54	2	2.2	60	3	10	6.82	1800	17
	4/21/54	1	4.0	90	4	20	6.90	1120	22
	5/ 4/54	1	1.2	10	1	15	7.20	250	4
	5/ 4/54	2	1.3	90	3.5	0	7.08	430	15
	5/11/54	1	2.8	80	4.0	10	6.60	770	17

During the time that the bulls of Group I were on the experimental ration, they gained at an average rate of 1.6 pounds per day for the three Holsteins and 1.1 pounds per day for the two Guernseys. This involved a period of 270 days on Ration I. Guernsey number 11 (with the injured forelegs) gained 0.8 pounds per day during the 270 day period and presented a generally unthrifty appearance. His legs gradually weakened as the experiment progressed. The other Guernsey, number 15, gained an average of 1.4 pounds per day for the entire period and was in good physical condition at all times. The three Holstein bulls were in good physical health throughout the experimental period. These bulls had been kept in digestion stalls for extended periods of time from early calfhood in order to get an estimate of the length of time that very young calves could be expected to remain in a fair state of health under such conditions. Therefore, they were not as growthy, nor were they as heavy when they were put on this experiment as they might have been under more nearly normal conditions.

The bulls of Group II were on the experimental ration a total of 104 days. During that time they gained an average of 46 pounds, or 0.44 pounds per day. These young bulls were not as thrifty in appearance as were those in Group I. The hair coat became somewhat rough and shaggy. However, they were alert and very little trouble was encountered in raising them. Tables 21 and 22 contain pertinent husbandry comments concerning the handling of both groups.

Table 21

Management of calves in Group I

Calf no.	Date	Remarks
	1953	
21	Mar. 8	Start of feed record
21	Mar. 8, 9, 12	Given 30 mg. Aureomycin
3,4	Mar. 14	Start of feed record
3	Mar. 26, 28	Scours. Given 8 grams of sulfathalidine
4	Mar. 27, 28	Scours. Given 8 grams of sulfathalidine
4	April 1	Given 4 grams sulfathalidine
3,4	April 7, 8	Given 400 mg. Aureomycin
21	Apr. 11-May 23	In digestion stalls
3	June 2	Given 1 rumentic tab
11,21	June 20-July 11	In digestion stalls
11	June 20	Start of feed record
15	July 16	Start of feed record
All	Aug. 5	Experimental ration fed
3	Aug. 9	Slight bloat
3	Aug. 31, Sept. 1, 3	Foot rot, treated with iodine
All	Sept. 6	Feet trimmed
All	Sept. 7	Hair clipped
All	Sept. 8	Start of digestion trial I preliminary period
All	Sept. 11	Start of digestion trial I
All	Sept. 22	End of digestion trial I
3	Sept. 11-22	Considerable weigh back
All	Nov. 28	Start of digestion trial II preliminary period
All	Dec. 9	Start of digestion trial II
All	Dec. 19	End of digestion trial II
34,15, & 21	1954 Feb. 17	Horns removed
All	May 1	Data ends

Table 22

Management of calves in Group II

Calf no.	Date	Remarks
	1953	
All	Oct. 3	Feed record started
36	Oct. 13, 14, Nov. 6 & 8	Scours
34	Oct. 27, 28, & 30	Scours
35	Oct. 27	Scours
37	Nov. 8	Scours
	1954	
All	Jan. 17	Experimental ration fed
All	Feb. 6	Start of digestion trial III preliminary period
All	Feb. 16	Start of digestion trial III
34	Feb. 16, 21	Urine very bloody
35	Feb. 17	Calf appeared sick
37	Feb. 17	Strong odor noticed in feces
All	Feb. 26	End of digestion trial III
34	Mar. 12	Chewed hair from tail
37	Mar. 20	Chewed hair from tail
All	Mar. 29	Start of digestion trial IV preliminary period
	April 5	Start of digestion trial IV
	April 15	End of digestion trial IV
	May 1	Data ends

General Acceptance of the Rations

There was no difficulty experienced in getting the Group I bulls on their ration or in keeping them on it. Group I bulls consistently consumed all feed that was offered them with the exception of the two digestion trial periods. Group II bulls refused some of their ration each week. Weighbacks were especially large during the two digestion trials in which they were involved. However, no

difficulty was experienced either in getting Group II bulls on their ration or in keeping them on it.

SUMMARY AND CONCLUSIONS

A long term feeding trial was initiated to test certain experimental rations thought suitable for use with growing dairy bulls. The ultimate use for these rations will be in the determination of the phosphorus requirements of young dairy bulls for growth and reproduction.

Two groups of young dairy bulls were used to test two rations that differed primarily in the phosphorus and calcium content and in the ratio of calcium to phosphorus. Group I, consisting of five bulls, was fed a ration calculated to contain two-thirds of the N.R.C. recommendations for phosphorus. These bulls were maintained on the experimental ration for 270 days and exhibited satisfactory growth and reproductive development. Group II, consisting of six bulls, was fed a ration calculated to contain approximately one-third of the N.R.C. recommended allowance for phosphorus for young growing cattle. This group was maintained on the experimental ration for 10½ days and exhibited a subnormal appearance in connection with a reduced growth rate.

Two digestion trials were conducted with each group to determine the utilization of the ration and apparent digestibility of nutrients involved. It was found that: (a) all animals in all trials showed positive phosphorus and calcium

balances; (b) with one exception nitrogen balances were positive; and (c) apparent digestibilities were satisfactory.

Blood plasma calcium and inorganic phosphorus levels remained at a normal level throughout the trial for Group I. Group II bulls maintained normal plasma calcium levels, but plasma inorganic phosphorus levels dropped.

Sexual development of the Group I bulls was apparently normal as determined by semen production.

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APPENDIX

Table I

Results of digestion trial I, Group I
Collection period: September 11-22, 1953

Calf no.	Body wt. (lb.)	Description	Dry matter	Ash	Organic matter	Ca	P	E.E.	C.F.	N
3	207	Intake (gm.)	16882	1000	15882	134.9	54.9	234	2616	424.3
		Outgo: feces (gm.)	5614	500	5114	110.0	21.9	183	16.38	144.4
		urine (gm.)				5.0	16.1			226.7
		Per cent digested	66.8		67.8			21.8	38.4	66.0
		Per cent retained				14.8	31.0			12.5
		Balance/day (gm.)				1.8	1.6			4.8
		Ret./cwt./day (gm.)				0.9	0.8			2.3
4	385	Intake (gm.)	44368	2603	40764	326.5	105.9	570	9484	869.9
		Outgo: feces (gm.)	12605	804	11801	162.6	24.0	203	5350	247.5
		urine (gm.)				8.2	1.5			254.7
		Per cent digested	71.6		71.7			64.4	43.6	71.5
		Per cent retained				47.7	76.0			42.3
		Balance/day (gm.)				14.2	7.3			33.5
		Ret./cwt./day (gm.)				3.7	1.9			8.7
11	226	Intake (gm.)	20688	1192	19496	163.4	61.6	307	3327	483.5
		Outgo: feces (gm.)	4315	351	3964	84.6	9.1	119	1270	117.4
		urine (gm.)				1.8	1.9			211.1
		Per cent digested	79.1		79.7			61.3	61.8	75.7
		Per cent retained				47.2	82.3			31.9
		Balance/day (gm.)				7.0	4.6			14.0
		Ret./cwt./day (gm.)				3.1	2.0			6.2

Table I (Continued)

Calf no.	Body wt. (lb.)	Description	Dry matter	Ash	Organic matter	Ca	P	M.E.	C.P.	N
15	236	Intake (gm.)	25291	1540	23751	209.3	75.9	400	4101	606.3
		Outgo: feces (gm.)	6528	542	5980	126.7	17.6	242	1949	162.7
		urine (gm.)				2.9	0.2			246.8
		Per cent digested	74.2	64.8	74.8			39.7	52.5	73.2
		Per cent retained				38.1	76.5			32.5
		Balance/day (gm.)				7.2	5.3			17.9
		Net./cwt./day (gm.)				3.1	2.2			7.6
21	283	Intake (gm.)	30248	1779	28469	232.1	80.6	421	5577	673.9
		Outgo: feces (gm.)	10585	752	9833	164.1	21.2	221	4005	243.9
		urine (gm.)				1.9	16.3			251.8
		Per cent digested	65.0	57.8	65.5			47.4	28.2	63.8
		Per cent retained				28.5	53.5			26.6
		Balance/day (gm.)				6.6	4.0			18.1
		Net./cwt./day (gm.)				2.1	1.4			6.4

Table II

Results of digestion trial II, Group I
Collection period: December 9-19, 1953

Calf no.	Body wt. (lb.)	Description	Dry matter	Ash	Organic matter	Ca	P	E.E.	C.F.	N
3	315	Intake (gm.)	28657	1889	26768	251.2	102.0	630	4836	739.6
		Outgo: feces (gm.)	10168	730	9437	154.6	35.2	313	4294	240.7
		urine (gm.)				7.3	8.9			188.0
		Per cent digested	64.5		64.7			50.4	11.2	67.5
		Per cent retained				29.5	53.4			42.0
		Balance/day (gm.)				7.4	5.4			31.1
		Ret./cwt./day (gm.)				2.3	1.7			9.9
4	544	Intake (gm.)	54155	3388	50766	402.1	133.2	848	12603	931.4
		Outgo: feces (gm.)	17855	1127	16728	235.7	47.3	205	7980	323.5
		urine (gm.)				19.6	4.6			223
		Per cent digested	67.0		67.0			75.8	36.6	65.3
		Per cent retained				57.6	61.0			41.4
		Balance/day (gm.)				14.7	8.0			38.5
		Ret./cwt./day (gm.)				2.7	1.5			7.1
11	300	Intake (gm.)	26408	1637	24771	216.0	80.3	319	5942	734.5
		Outgo: feces (gm.)	6391	403	5989	108.3	15.7	125	2707	126.1
		urine (gm.)				6.4	25.4			278.0
		Per cent digested	75.8		75.8			60.9	54.4	82.8
		Per cent retained				46.7	46.9			58.6
		Balance/day (gm.)				10.1	3.9			43.0
		Ret./cwt./day (gm.)				3.4	1.3			14.3

Table II (Continued)

Calf no.	Body wt. (lb.)	Description	Dry matter	Ash	Organic matter	Ca	P	N.F.	C.F.	N
15	331	Intake (gm.)	38977	2499	36478	319.1	118.6	774	7679	803.4
		Outgo: feces (gm.)	10791	861	9930	206.3	43.1	227	3983	261.6
		urine (gm.)				6.7	12.7			206.0
		Per cent digested	72.3		72.8			70.7	48.1	67.4
		Per cent retained				32.6	53.0			41.7
		Balance/day (gm.)				10.4	6.3			33.5
		Ret./cwt./day (gm.)				3.1	1.9			10.1
21	407	Intake (gm.)	44949	2846	42103	350.4	123.3	795	9549	847.5
		Outgo: feces (gm.)	10166	679	9487	151.5	33.0	266	4050	204.7
		urine (gm.)				12.7	12.1			194.0
		Per cent digested	77.4		77.5			66.5	57.6	75.8
		Per cent retained				53.2	63.4			52.9
		Balance/day (gm.)				18.6	7.8			44.9
		Ret./cwt./day (gm.)				4.6	1.9			11.0

Table III

Results of digestion trial III, Group II
Collection Period: February 16-26, 1954

Calf no.	Body wt. (lb.)	Description	Dry matter	Ash	Organic matter	Ca	P	E.E.	C.F.	N
33	255	Intake (gm.)	24007	1134	22873	172.0	36.5	362	4406	452.6
		Outgo: feces (gm.)	5175	351	4823	74.5	20.0	155	2075	132.4
		urine (gm.)				12.0	0.5			194
		Per cent digested	78.5		78.9			57.1	52.9	70.7
		Per cent retained				49.7	44.0			27.9
		Balance/day (gm.)				8.5	1.6			12.6
		Ret./cwt./day (gm.)				3.4	0.6			4.9
34	212	Intake (gm.)	21150	1009	20141	161.0	34.1	308	3620	433.1
		Outgo: feces (gm.)	4492	302	4190	58.9	20.0	157	1708	124.3
		urine (gm.)				21.6	0.3			178
		Per cent digested	78.8		79.2			49.1	52.8	71.3
		Per cent retained				50.0	40.6			30.2
		Balance/day (gm.)				8.1	1.4			13.1
		Ret./cwt./day (gm.)				3.8	0.7			6.2
35	213	Intake (gm.)	11590	483	16107	99.2	18.4	322	2298	172.4
		Outgo: feces (gm.)	1904	129	1774	28.0	10.1	87	716	59.4
		urine (gm.)				12.0	0.2			174
		Per cent digested	83.6		84.0			73.0	68.9	65.6
		Per cent retained				59.7	43.9			-35.4
		Balance/day (gm.)				5.9	0.8			- 6.1
		Ret./cwt./day (gm.)				2.8	0.4			- 2.9

Table III (Continued)

Calf no.	Body wt. (lb.)	Description	Dry matter	Ash	Organic matter	Ca.	P	E.E.	C.F.	N
36	198	Intake (gm.)	19235	857	18379	146.8	31.6	278	2950	363.8
		Outgo: feces (gm.)	4260	287	3973	57.5	18.7	146	1652	117.9
		urine (gm.)				26.4	0.2			80.9
		Per cent digested	77.9		78.4			47.5	44.0	67.6
		Per cent retained				42.9	40.0			22.2
		Balance/day (gm.)				6.3	1.3			8.1
		Ret./cwt./day (gm.)				3.2	0.6			4.1
37	232	Intake (gm.)	24072	1180	22892	185.6	38.5	326	3695	551.9
		Outgo: feces (gm.)	4957	378	4585	68.2	22.4	201	1931	132.9
		urine (gm.)				22.5	0.1			270
		Per cent digested	79.4		80.0			38.5	47.7	75.9
		Per cent retained				40.3	41.6			27.0
		Balance/day (gm.)				7.5	1.6			14.9
		Ret./cwt./day (gm.)				3.2	0.7			6.4
38	239	Intake (gm.)	24577	1125	23452	183.8	37.8	362	4450	535.7
		Outgo: feces (gm.)	6442	402	6040	95.3	24.5	157	2428	170.8
		urine (gm.)				17.6	0.2			240
		Per cent digested	73.8		74.3			56.8	45.4	68.1
		Per cent retained				38.5	35.7			23.3
		Balance/day (gm.)				7.1	1.3			12.5
		Ret./cwt./day (gm.)				3.0	0.5			5.2

Table IV

Results of digestion trial IV, Group II
Collection period: April 5-15, 1954

Calf no.	Body wt. (lb.)	Description	Dry matter	Ash	Organic matter	Ca	P	M.E.	C.F.	N
33	285	Intake (gm.)	22383	1056	21327	132.6	31.6	445	3955	476.8
		Outgo: feces (gm.)	5977	457	5520	101.0	14.3	105	2570	145.4
		urine (gm.)				6.4	0.5			210
		Per cent digested	73.3		74.1			76.5	35.0	69.5
		Per cent retained				19.0	53.0			25.5
		Balance/day (gm.)				2.5	1.7			12.1
		Ret./cwt./day (gm.)				0.9	0.6			4.3
34	219	Intake (gm.)	16752	773	15979	93.9	24.3	361	2884	351.5
		Outgo: feces (gm.)	2231	235	1997	45.7	7.4	53	674	74.6
		urine (gm.)				20.6	0.3			165.6
		Per cent digested	86.7		87.5			85.4	76.6	78.8
		Per cent retained				29.3	71.4			31.7
		Balance/day (gm.)				2.8	1.7			11.1
		Ret./cwt./day (gm.)				1.3	0.8			5.1
35	236	Intake (gm.)	16582	794	15788	101.5	23.9	396	2806	399.8
		Outgo: feces (gm.)	2208	427	1780	46.8	11.3	76	680	64.6
		urine (gm.)				16.9	0.2			210
		Per cent digested	86.7		88.7			80.6	75.8	83.8
		Per cent retained				37.3	52.0			31.3
		Balance/day (gm.)				3.8	1.2			12.5
		Ret./cwt./day (gm.)				1.6	0.5			5.3

Table IV (Continued)

Calf no.	Body wt. (lb.)	Description	Dry matter	Ash	Organic matter	Ca	P	N.E.	O.E.	N
36	207	Intake (gm.)	14223	575	13649	79.0	20.3	318	2872	218.0
		Outgo: feces (gm.)	2618	254	2364	54.7	13.1	32.0	832	74.2
		urine (gm.)				12.0	0.2			124
		Per cent digested	81.6		82.7			90.0	71.0	66.0
		Per cent retained				15.6	34.5			90.8
		Balance/day (gm.)				1.2	0.7			2.0
		Ret./cwt./day (gm.)				0.6	0.3			1.0
37	260	Intake (gm.)	20253	923	19329	126.0	28.5	485	3341	476.1
		Outgo: feces (gm.)	4086	380	3706	80.5	14.3	179	1267	101.4
		urine (gm.)				17.6	.2			210
		Per cent digested	79.8		80.8			63.0	62.1	78.7
		Per cent retained				22.1	49.1			34.6
		Balance/day (gm.)				2.8	1.4			16.5
		Ret./cwt./day (gm.)				1.1	0.5			6.3
38	272	Intake (gm.)	21613	997	20617	125.4	28.9	601	3804	462.9
		Outgo: feces (gm.)	3525	326	3199	74.4	14.5	115	1057	80.6
		urine (gm.)				14.0	0.3			198
		Per cent digested	83.7		84.5			76.0	72.8	80.6
		Per cent retained				29.5	49.1			39.6
		Balance/day (gm.)				3.7	1.4			18.3
		Ret./cwt./day (gm.)				1.4	0.5			7.7

Table V

Body weight (lb.), total feed consumption (lb.), feces (gm.) and urine (gm. or l.) for digestion trials

Calf no.	Starter	Pulp molasses	Beet pulp	Weigh back	Body wt. 9/11	Body wt. 9/22	Bwt. gain	Outgo Feces(gm.)	Outgo Urine(gm.)	Remarks
Digestion Trial I - Sept. 11-22, 1953										
3	51.7	17.6		27.8	219	194	- 25	32080	75.069	Polyurea
4	59.4	51.6		1.3	377	393	16	61080	43.753	
11	51.7	19.8		20.7	226	225	- 1	22570	30.733	
15	51.7	19.8		9.7	226	246	20	31280	68.935	
21	56.1	27.5		9.3	268	298	30	46020	83.944	
Digestion Trial II - Dec. 9-19, 1953										
3	53	25	--	9.3	300	330	30	49842	100	
4	58	74	10.00	--	520	563	43	95992	100	
11	53	37	--	25.9	300	300	0	25372	100	9 1/2 days
15	54	40	--	--	310	352	42	45342	100	on trial
21	55	54	--	--	395	418	23	45791	100	

Table V (Continued)

Digestion Trial III - Feb. 16-26, 1954

Calf no.	Starter	Pulp molasses	Weigh back	Body wt. 2/16	Body wt. 2/26	Bwt. gain	Outgo Feces(gm.)	Outgo Urine(l.)	Remarks
33	48	20	7.7	254	255	1	20372	100	Bloody
34	47	16	10.0	218	206	- 12	23896	100	urine
35	47	16	34.0	218	208	- 10	7614	100	
36	46	14	11.8	197	198	1	15718	100	
37	48	16	3.7	230	234	4	21094	100	
38	49	20	7.3	227	251	24	29961	100	

Digestion Trial IV - April 5-15, 1954

Calf no.	Starter	Pulp molasses	Weigh back	Body wt. 4/5	Body wt. 4/15	Bwt. gain	Outgo Feces(gm.)	Outgo Urine(l.)	Remarks
33	48	19	11.4	274	295	21	25876	50	Loose feces
34	48	18	25.3	219	219	0	11743	80	
35	48	19	26.5	230	242	12	7941	50	
36	47	16	28.3	198	215	17	10146	50	
37	50	23	23.9	250	269	19	12160	50	
38	50	25	22.5	265	278	13	9500	50	

Table VI

Percentage composition of digestion trial components
Intake - air dry sample base

Sample description	Calf no.	Dry matter	Ash	Organic matter	E.E.	C.F.	NFE	Ca	P	N
				Digestion trial no. I						
Starter ration	--	91.84	5.95	85.89	1.99	8.77	57.75	0.88	0.35	2.78
Pulp molasses	--	66.15	5.52	81.73	.183	30.90	47.23	0.40	0.054	0.56
Weigh back	3	91.46	5.93	85.53	1.96	15.13	54.94	0.82	0.25	2.16
Weigh back	4	91.84	5.82	86.02	1.53	18.94	54.74	0.71	0.17	1.73
Weigh back	11	91.45	6.39	85.06	1.88	16.03	52.59	0.84	0.27	2.33
Weigh back	15	90.54	5.73	84.81	1.88	16.62	52.68	0.75	0.25	2.18
Weigh back	21	91.71	6.78	84.93	2.57	12.07	54.98	0.99	0.36	2.45
				Digestion trial no. II						
Starter ration	--	94.46	6.50	87.96	3.07	8.44	58.20	0.99	0.454	2.92
Pulp molasses	--	87.30	5.00	82.30	0.12	30.93	48.21	0.422	0.041	0.486
Weigh back	3	93.68	5.71	87.97	3.52	16.60	65.77	0.82	0.30	0.416
Weigh back	11	93.23	6.51	86.72	3.74	16.79	64.12	0.79	0.304	0.418
				Digestion trial no. III						
Starter ration	--	88.81	4.14	84.67	0.70	6.87	60.22	0.76	0.176	2.70
Pulp molasses	--	85.60	5.29	80.31	2.58	33.62	43.53	0.43	0.034	0.33
Weigh back	33	88.62	7.08	81.54	0.70	4.01	47.27	0.93	0.14	4.73
Weigh back	34	88.10	5.67	82.43	0.63	6.27	52.59	0.71	0.13	3.67
Weigh back	35	87.90	5.08	82.82	0.95	10.42	54.14	0.61	0.14	2.77
Weigh back	36	88.38	6.41	81.97	0.59	4.49	51.14	0.73	0.14	4.12
Weigh back	37	87.99	6.25	81.74	0.79	7.56	51.08	0.66	0.14	3.57
Weigh back	38	88.40	6.61	81.81	0.83	12.59	50.58	0.73	0.12	2.85

Table VI (Continued)

Sample description	Calf no.	Dry matter	Ash	Organic matter	N.E.	C.F.	NFE	Ca	P	N
				Digestion trial no. IV						
Starter ration	--	90.15	4.40	85.35	1.02	6.6	58.8	0.65	0.16	3.03
Pulp molasses	--	84.70	5.28	84.70	0.10	31.5	46.1	0.40	0.04	0.47
Weigh back	33	88.10	6.90	81.20	1.13	3.8	49.3	0.84	0.13	4.32
Weigh back	34	85.42	5.37	80.05	1.11	9.8	50.3	0.70	0.12	3.02
Weigh back	35	86.06	5.15	81.01	0.39	11.2	53.3	0.62	0.12	2.50
Weigh back	36	86.88	5.82	81.06	1.06	6.4	50.7	0.69	0.13	3.66
Weigh back	37	83.42	5.77	77.65	0.80	13.3	45.6	0.61	0.11	2.40
Weigh back	38	82.83	5.88	76.95	0.00	11.6	48.4	0.66	0.09	2.70

Table VII

Percentage composition of digestion trial components
Outgo: feces - air dry sample

Calf no.	Dry matter*	HOH	Ash	Organic matter	E.E.	C.F.	NFE	Ca	P	N*
				Digestion trial no. I						
3	17.50	6.21	8.62	85.17	3.26	29.18	49.51	1.90	0.38	0.45
4	20.37	4.93	6.22	88.85	1.61	42.44	41.70	1.26	0.19	0.40
11	19.12	2.86	7.93	89.21	2.75	29.43	53.12	1.91	0.20	0.52
15	20.87	3.28	8.04	88.68	3.70	29.86	51.16	1.88	0.26	0.52
21	23.00	2.68	6.91	90.41	2.09	37.84	46.39	1.51	0.19	0.53
				Digestion trial no. II						
3	20.4	3.55	6.54	93.46	2.90	43.78	31.98	1.52	0.334	0.483
4	18.6	1.84	6.31	93.69	1.17	45.58	35.60	1.32	0.260	0.337
11	25.1	2.99	6.30	93.70	2.01	43.67	35.63	1.70	0.240	0.497
15	23.8	2.71	7.98	92.02	2.16	37.94	36.75	1.93	0.388	0.577
21	22.2	3.47	6.68	93.36	2.71	41.27	36.81	1.49	0.314	0.447
				Digestion trial no. III						
33	25.4	0	6.79	93.21	3.00	40.10	34.13	1.44	0.386	0.65
34	18.8	0	6.73	93.27	3.49	38.02	34.47	1.31	0.444	0.52
35	25.0	0	6.79	93.21	4.56	37.59	31.54	1.47	0.532	0.78
36	27.1	0	6.73	93.27	3.45	38.78	33.73	1.35	0.440	0.75
37	23.5	0	7.62	92.38	4.05	30.96	32.61	1.78	0.452	0.63
38	21.5	0	6.24	93.76	2.43	37.69	37.08	1.48	0.380	0.57

Table VII (Continued)

Calf no.	Dry matter*	HOH	Ash	Organic matter	E.E.	C.F.	NFE	Ca	P	N*
				Digestion trial no. IV						
33	23.1	0	7.65	92.35	1.75	43.00	44.09	1.69	0.24	0.562
34	19.0	0	10.51	89.65	2.37	30.20	52.95	2.05	0.33	0.635
35	27.8	0	9.35	90.65	3.46	30.80	51.30	2.12	0.51	0.814
36	25.8	0	9.69	90.31	2.53	31.80	51.41	2.09	0.50	0.731
37	33.6	0	9.30	90.70	4.39	31.00	50.10	1.97	0.35	0.834
38	37.1	0	9.24	90.76	3.25	30.00	52.21	2.11	0.41	0.850

* Fresh sample

Table VIII

Percentage composition of digestion trial components
Outgo: urine

Trial no.	Calf no.	Specific gravity	Ca mg./100 ml.	P mg./100 ml.	N mg./100 ml.
I	3	1.0076	6.6	21.8	302
	4	1.0222	18.7	3.5	582
	11	1.0178	5.6	6.1	687
	15	1.0108	4.2	0.3	358
	21	1.0096	2.2	19.4	300
II	3	1.0000	7.33	8.88	188
	4	1.0000	19.55	4.56	223
	11	1.0000	6.44	25.36	278
	15	1.0000	6.67	12.72	206
	21	1.0000	12.67	12.12	194
III	33	1.0000	12.0	0.194	194
	34	1.0000	21.6	0.178	178
	35	1.0000	12.0	0.174	174
	36	1.0000	26.4	0.165	165
	37	1.0000	24.8	0.270	270
	38	1.0000	17.6	0.240	240
IV	33	1.0000	12.8	1.02	358
	34	1.0000	25.8	0.40	207
	35	1.0000	33.8	0.37	420
	36	1.0000	24.0	0.45	248
	37	1.0000	35.2	0.47	420
	38	1.0000	28.0	0.50	396

Specific gravity values for trials II, III and IV are assumed.

Table IX

Average results of each digestion trial

Trial no.	Body wt. (lb.)	Description	Dry matter	Ash	Organic matter	Ca	P	E.E.	C.F.	N
(Group I)										
I	267	Intake (gm.)	27495	1623	25672	213.2	75.6	386	5021	611.6
		Outgo: feces (gm.)	7929	590	7340	129.6	18.8	194	2842	183.2
		urine (gm.)				4.0	7.3			230.2
		Per cent digested	71.3		71.9			46.9	44.7	70.0
		Per cent retained				35.3	63.9			29.2
		Balance/day (gm.)				7.2	4.6			17.7
		Ret./cwt./day (gm.)				2.6	1.7			6.2
II	379	Intake (gm.)	38629	2452	36177	307.8	111.4	673	8122	811.3
		Outgo: feces (gm.)	11074	760	10314	171.7	34.9	227	4604	231.3
		urine (gm.)				10.5	12.7			217.9
		Per cent digested	71.4		71.6			64.9	41.6	71.7
		Per cent retained				43.9	55.9			47.3
		Balance/day (gm.)				12.2	6.3			38.2
		Ret./cwt./day (gm.)				3.2	1.7			10.5
(Group II)										
III	225	Intake (gm.)	20772	965	19807	158.1	32.8	326	3570	418.3
		Outgo: feces (gm.)	4538	308	4231	67.1	19.3	151	1752	123.0
		urine (gm.)				18.7	0.3			189.5
		Per cent digested	78.7		79.1			53.7	52.0	69.9
		Per cent retained				46.9	41.0			15.9
		Balance/day (gm.)				7.2	1.3			9.2
		Ret./cwt./day (gm.)				3.2	0.6			4.0

Table IX (Continued)

Trial no.	Body wt. (lb.)	Description	Dry matter	Ash	Organic matter	Ca	P	E.E.	C.F.	N
IV	247	Intake (gm.)	18634	853	17782	109.7	26.3	434	3290	397.5
		Outgo: feces (gm.)	3441	347	3094	67.2	12.5	93	1180	90.1
		urine (gm.)				14.6	0.3			186.3
		Per cent digested	82.0		83.1			78.6	65.6	76.2
		Per cent retained				25.5	51.5			42.3
		Balance/day (gm.)				2.8	1.3			12.1
		Ret./cwt./day (gm.)				1.2	0.5			5.0

Table X

Percentage composition of feed used to calculate consumption data for Groups I and II

Description	Dry matter	Protein	TDN	P	Ca
Concentrate I	87	17.9	74.3	0.31	0.87
Concentrate II	85	16.7	72.3	0.10	0.66
Pulp-molasses	87	2.58	41.00	0.06	0.40
Beet pulp	90	7.6	72.00	0.06	0.83
Herd starter	91	14.5	75.00	0.25*	1.73*
Group II weigh back	88	23.5	65.00	0.12	0.71
Prairie hay	94	1.75	51.00	0.18*	0.36*
Alfalfa hay	94	10.00	53.6	0.25*	1.73*
Milk	--	3.30*	16.3*	0.06*	0.83*

* Values reported here were taken from Morrison's Feeds and Feeding, 21st ed., 1949.

Table XI

Growth measurements and feed consumption for Holstein bull no. 3, Group I
Born February 2 - purchased March 14

Date period ended		Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Herd starter consumed (lb.)	Alfalfa hay consumed (lb.)	Milk consumed (lb.)	Conc. I consumed (lb.)	Pulp-molasses consumed (lb.)	Beet pulp consumed (lb.)	Est. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
March	21	88	30.00	29.50	0.9	1.1	28				5.8	1.2	26.1	15.5
	28	97	29.50	30.00	0.9	1.2	70				12.7	2.6	49.8	32.8
April	4	70	27.50	28.50	1.6	2.2	63				12.6	2.5	55.5	33.3
	11	80	28.50	29.00	3.1	3.0	55				12.9	2.6	61.2	35.8
	18	80	29.25	29.50	4.6	4.0	28				10.3	2.0	58.6	31.3
	25	85	29.50	29.75	12.6	6.1					13.8	2.0	95.0	49.2
May	2	92	29.75	30.50	16.8	7.4					16.6	2.6	100.0	61.9
	9	101	31.00	30.50	23.1	5.9					20.5	3.2	103.9	81.4
	16	109	31.75	31.50	24.9	13.0					25.7	4.9	164.1	94.0
	23	125	32.00	31.50	29.6	16.9					31.3	6.0	206.5	113.2
	30	130	32.75	32.50	31.3	13.4					30.7	5.9	183.2	114.6
June	6	130	32.75	32.50	29.5	13.5					29.4	5.6	179.5	109.0
	13	119	32.75	32.50	25.6	12.9					26.1	5.0	165.1	95.9
	20	125	33.50	32.75	17.3	12.0					19.4	3.7	137.3	60.5
	27	131	34.00	33.00	16.4	14.1					19.9	3.8	151.6	68.1
July	4	136	34.75	33.25	18.7	16.2					22.7	4.3	173.8	77.7
	11	142	35.50	33.50	18.0	14.3					21.2	4.0	157.1	73.4
	18	148	36.00	33.75	13.6	17.3					19.5	3.7	169.7	62.8
	25	154	36.75	34.00	21.0	15.1					23.8	4.6	170.9	83.8

Table XI (Continued)

Date period ended	Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Herd starter consumed (lb.)	Alfalfa hay consumed (lb.)	Milk consumed (lb.)	Conc. M consumed (lb.)	Pulp-molasses consumed (lb.)	Beet pulp consumed (lb.)	Est. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
August 1	159	37.25	34.25	25.4	11.3					25.1	4.8	152.0	93.5
4	165	38.00	34.50	0.0	5.0					8.7	1.7	59.2	31.1
11	174	38.00	35.00				29.3	2.8		22.9	5.3	120.7	42.0
18	174	38.50	35.00				29.8	4.0		23.8	5.4	124.9	43.0
25	200	39.75	35.25				30.1	5.6		24.7	5.5	128.9	43.8
Sept. 1	209	39.75	35.50				31.5	9.1		27.1	5.9	140.8	46.8
8	208	40.50	35.75				32.9	11.2		29.0	6.2	150.2	49.3
11	219	41.50	36.00				13.2	4.8		11.8	2.5	60.8	20.0
22	194	40.50	37.00				37.7	5.3		30.2	6.9	158.4	54.5
29	215	41.50	37.75				32.9	11.2		29.0	6.2	150.2	49.3
Oct. 6	228	43.00	37.00				31.9	12.6		28.9	6.0	148.7	48.3
13	240	43.00	38.00				33.6	14.0		30.7	6.4	158.0	51.1
24	249	44.50	38.00				49.0	21.0		45.0	9.3	231.5	74.6
31	259	44.50	38.25				35.0	16.1		32.6	6.7	167.3	53.6
Nov. 7	283	45.00	39.50				35.0	25.0		36.3	6.9	183.5	56.0
14	285	45.50	39.50				36.4	13.3		32.50	6.9	167.8	54.8
21	307	46.50	40.00				36.4	13.3		32.5	6.9	167.8	54.8
28	306	47.50	40.00				37.1	24.5		37.6	7.3	190.9	58.8
Dec. 9	300	47.50	40.50				58.3	38.5		59.1	11.4	300.0	92.5
19	330	49.00	41.00				48.9	35.0		50.7	9.7	256.5	78.3
26	335	49.50	41.00				37.8	27.3		39.3	7.5	198.7	60.6

TABLE XI (Continued)

Date period ended	Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Herd starter consumed (lb.)	Alfalfa hay consumed (lb.)	Milk consumed (lb.)	Conc. I consumed (lb.)	Pulp-molasses consumed (lb.)	Beet pulp consumed (lb.)	Est. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
(1954)													
Jan. 2	348	49.50	41.75				39.8	28.7		41.3	7.9	209.1	63.8
9	343	49.25	41.50				37.8	28.7		39.9	7.5	201.2	61.0
16	350	51.00	42.00				37.8	28.7		39.9	7.5	201.2	61.0
23	355	51.00	42.50				37.8	29.4		40.1	7.5	202.5	61.2
30	360	51.00	42.25				37.8	29.4		40.1	7.5	202.5	61.2
Feb. 6	367	51.75	43.00				37.8	28.0		39.6	7.5	200.0	60.8
13	406	52.50	42.50				38.5	28.7		40.4	7.6	204.0	61.9
20	388	52.50	42.75				33.5	32.9	7.0	47.1	7.7	238.0	65.0
27	405	53.25	43.50				38.5	32.9	7.0	47.1	8.3	238.0	65.0
March 6	429	53.75	44.00				38.5	32.9	7.0	47.1	8.3	230.0	65.0
13	440	54.25	43.50				39.2	35.0	7.0	48.5	8.5	244.6	66.7
20	473	54.75	44.25				39.2	36.4	7.0	49.1	8.5	247.1	66.9
27	497	56.00	44.50				39.2	40.6	7.0	50.8	8.6	254.7	68.1
April 3	505	56.25	44.00				39.9	44.1	7.0	52.8	8.8	263.8	70.0
10	483	55.50	44.75				39.9	44.1	7.0	52.8	8.8	263.8	70.0
17	531	56.00	45.00				39.9	41.3	7.0	51.6	8.7	258.7	69.3
24	495	56.75	45.00				39.9	43.3	7.0	54.5	8.9	271.4	71.2
May 1	530	57.50	45.50				39.9	43.3	7.0	54.5	8.9	271.4	71.2

Table XII

Growth measurements and feed consumption for Holstein bull no. 4, Group I
Born February 14

Date period ended		Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Hard starter consumed (lb.)	Alfalfa hay consumed (lb.)	Milk consumed (lb.)	Conc. I consumed (lb.)	Pulp-molasses consumed (lb.)	Beet pulp consumed (lb.)	Est. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
March	14	53	25.25	27.50										
	21	55	25.50	27.50	1.6	1.4	56				11.1	2.2	45.0	29.6
	28	62	26.25	28.00	1.1	1.3	70				12.9	2.6	50.8	33.7
April	4	71	27.00	28.00	1.0	0.7	63				11.4	2.3	42.0	30.0
	11	100	30.50	29.75	5.4	2.7	55				14.5	2.9	64.4	42.8
	18	125	32.50	31.50	7.8	4.1	42				14.9	2.9	74.3	46.7
	25	135	33.75	32.00	16.0	7.4	28				20.5	3.1	113.1	70.8
May	2	160	34.50	32.50	23.4	8.8					22.3	4.3	127.4	84.3
	9	165	35.25	32.75	34.3	11.0					32.1	6.2	178.0	122.4
	16	170	36.00	33.00	32.2	12.9					31.1	6.0	161.5	117.0
	23	193	37.00	34.00	35.0	16.5					35.1	6.7	216.7	130.0
	30	210	38.25	34.25	35.0	13.9					33.7	6.5	196.3	127.0
June	6	200	39.00	34.50	35.0	18.0					35.9	6.9	228.5	131.6
	13	218	39.50	35.50	35.0	31.3					43.3	8.3	336.8	147.2
	20	228	40.00	35.75	35.0	38.8					43.7	8.0	391.7	155.1
	27	237	40.50	36.00	35.0	32.0					43.4	8.3	338.4	147.5
July	4	247	41.00	36.50	35.0	32.4					43.6	8.3	341.5	147.9
	11	256	41.50	36.75	35.0	31.0					42.9	8.2	330.5	146.3
	18	266	42.00	37.25	35.0	34.6					44.8	8.5	358.8	150.4
	25	276	42.50	37.50	35.0	36.5					46.9	6.9	369.4	154.8

Table XII (Continued)

Date period ended	Body weight	Heart girth	Height at withers	Herd starter consumed	Alfalfa hay consumed	Milk consumed	Conc. I consumed	Pulp-molasses consumed	Beet pulp consumed	Est. TDN consumed	Total protein consumed	Calcium consumed	Phosphorus consumed
	(lb.)	(in.)	(in.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(gm.)	(gm.)
August 1	285	43.00	38.00	35.0	42.2					48.9	9.3	418.4	159.0
4	295	43.50	38.25	35.0	12.0					13.6	2.7	181.4	124.9
11	303	45.00	38.25				34.9	20.6		34.4	6.8	175.2	54.8
18	320	46.50	38.75				37.1	22.4		36.8	7.2	187.1	58.4
25	344	47.50	39.25				37.8	25.9		38.7	7.4	196.2	60.3
Sept. 1	360	49.75	39.25				37.8	29.4		40.1	7.5	202.5	61.2
8	366	49.75	40.00				37.8	32.2		41.3	7.6	207.6	62.0
11	377	51.00	39.00				16.2	14.1		17.8	3.3	89.5	26.7
22	393	49.75	41.00				58.1	51.7		64.4	11.7	323.1	95.9
29	406	50.50	41.00				38.5	37.1		43.8	7.9	219.2	64.3
Oct. 6	417	51.50	41.25				38.5	32.2	7.0	45.9	8.3	236.7	64.9
13	432	52.00	41.25				38.5	33.6	7.0	47.4	8.3	212.9	65.3
24	468	52.50	41.50				61.6	55.0	7.0	73.4	13.0	369.2	103.6
31	468	53.25	43.00				39.2	39.2	7.0	50.2	8.6	252.1	67.7
Nov. 7	490	53.50	42.75				39.2	39.2	7.0	50.2	8.6	252.1	67.7
14	504	54.00	42.75				39.9	42.7	7.0	52.2	8.8	261.2	69.7
21	521	54.75	43.50				39.2	44.8	7.0	52.5	8.7	235.9	69.3
28	562	56.00	44.50				39.9	53.9	7.0	59.7	9.4	281.5	72.7
Dec. 9	520	56.50	44.00				63.8	81.4	11.0	88.0	14.3	440.7	114.9
19	563	56.50	44.75				58.0	74.0	10.0	78.5	12.8	400.6	104.5
26	588	57.50	44.75				40.6	51.8	7.0	56.4	9.1	280.5	73.1

Table XII (Continued)

	Date reported	Body weight (lbs.)	Heart rate (in.)	Height at withers (in.)	Hard starter consumed (lbs.)	Alfalfa hay consumed (lbs.)	Milk consumed (lbs.)	Conc. I consumed (lbs.)	Palm-molasses consumed (lbs.)	Beet pulp consumed (lbs.)	Est. TDN consumed (lbs.)	Total protein consumed (lbs.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
(1954) Jan.	2	600	57.50	45.25				40.6	56.0	7.00	59.2	6.2	239.1	74.3
	9	645	58.00	45.50				40.3	57.4	7.00	56.7	6.3	290.8	74.3
	16	630	60.00	46.00				41.3	63.7	7.00	61.9	6.6	304.8	77.3
	23	610	60.00	46.00				41.3	63.7	7.00	61.9	6.6	304.8	77.3
	30	632	59.25	47.00				44.3	63.7	7.00	61.9	6.5	304.8	77.3
Feb.	6	634	61.00	47.25				44.3	63.7	7.00	61.9	6.5	299.7	76.8
	13	625	62.00	46.25				44.3	63.7	7.00	61.9	6.5	301.0	77.7
	20	612	60.25	46.50				44.3	63.7	7.00	62.4	6.5	306.3	77.7
	27	654	61.50	47.50				44.3	63.7	7.00	62.4	6.5	307.3	77.3
March	6	657	61.50	47.50				44.3	63.7	7.00	62.4	6.5	307.3	77.3
	13	724	62.00	47.25				41.3	70.0	7.00	66.0	6.7	304.8	77.3
	20	751	63.00	47.50				43.4	70.0	7.00	66.0	10.1	324.1	82.0
	27	783	63.25	48.00				43.4	70.0	7.00	66.0	10.1	324.1	82.0
April	3	775	63.50	48.00				43.4	77.0	7.00	66.0	10.1	324.1	82.0
	10	815	65.00	48.25				46.4	84.0	7.00	70.9	10.5	348.1	87.0
	17	785	65.00	48.50				43.4	84.0	7.00	70.7	10.5	349.0	85.0
May	24	805	64.50	49.00				43.4	84.0	7.00	72.7	10.5	349.0	85.0
	1													

Table XIII

Growth measurements and feed consumption for Guernsey bull no. 11, Group I
Born April 8

Date period ended		Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Herd starter consumed (lb.)	Alfalfa hay consumed (lb.)	Milk consumed (lb.)	Conc. I consumed (lb.)	Pulp-molasses consumed (lb.)	Beet pulp consumed (lb.)	Mat. FDM consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
June	19	145	37.00	33.00										
	26	151	37.50	33.50	11.8	6.5	10.0				13.2	2.7	85.8	49.0
July	3	155	38.00	33.75	8.8	4.6					8.5	1.7	58.0	33.2
	10	161	38.50	34.25	10.0	5.8					9.9	2.1	70.4	38.4
	17	166	39.00	34.50	21.7	11.6					21.0	4.3	145.1	82.1
	24	171	39.50	35.00	20.0	5.0					23.4	9.9	115.3	95.6
	31	177	40.00	35.50	28.0	6.8					23.0	10.9	123.1	96.7
Aug.	4	182	40.50	35.75	16.0	8.2					15.4	10.5	104.2	25.3
	11	196	41.00	36.00							27.2	6.2	143.0	49.3
	18	203	41.75	36.50				34.1	4.6		24.0	5.1	124.2	41.1
	25	213	42.25	36.50				27.5	8.6		28.0	6.0	144.9	48.1
Sept.	1	214	42.50	37.50				32.2	9.8		28.5	6.1	147.7	49.0
	8	220	43.50	37.75				32.9	9.8		29.0	6.2	150.2	49.4
	11	226	44.00	38.00				32.9	11.2		12.2	2.6	63.6	21.0
	22	225	43.25	38.25				14.1	4.2		31.2	6.1	150.3	49.1
	29	228	43.50	38.25				31.0	19.8		30.1	6.3	155.5	50.8
Oct.	6	244	45.25	38.50				33.6	12.6		30.7	6.4	158.1	51.2
	13	248	45.25	39.50				33.6	14.0		31.6	6.5	163.4	52.5
	24	263	47.50	39.50				34.3	15.4		31.1	10.6	263.0	85.1
	31	280	47.00	40.00				35.9	23.3		33.7	6.0	172.7	55.1
Nov.	7	296	47.50	40.50				36.7	17.3		41.9	7.0	179.3	58.6
	14	315	48.00	41.00				36.4	19.6		44.6	8.0	223.3	65.5
								39.2	37.8					

Table XIII (Continued)

Date period ended		Body weight	Heart girth	Height at withers	Herd starter consumed	Alfalfa hay consumed	Milk consumed	Conc. I consumed	Pulp-molasses consumed	Beet pulp consumed	Est. TDN consumed	Total protein consumed	Calcium consumed	Phosphorus consumed
		(lb.)	(in.)	(in.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(gm.)	(gm.)
Nov.	21	321	48.50	41.50				37.1	25.2		37.9	7.3	192.2	52.3
	28	325	49.25	42.50				37.1	25.2		39.2	7.3	192.2	52.3
Dec.	9	300	49.00	41.00				63.6	25.9		65.5	12.5	293.1	96.7
	19	300	48.75	41.00				49.6	44.4		43.6	9.3	276.3	81.9
	26	313	48.25	40.75				45.0	16.5		44.1	8.7	207.6	67.9
Jan.	2	309	48.50	41.50				35.2	25.9		36.8	7.0	185.9	56.6
	9	325	49.50	41.50				37.1	25.9		38.2	7.3	193.4	59.3
	16	312	49.00	42.00				37.8	25.9		38.4	7.4	196.2	60.3
	23	325	50.00	42.00				37.8	25.2		38.4	7.4	194.9	60.1
	30	335	49.00	42.25				37.8	25.2		38.4	7.4	194.9	60.1
Feb.	6	318	50.50	42.50				37.8	25.2		38.7	7.4	194.9	60.1
	13	323	50.50	39.5				37.1	25.9		38.2	7.3	193.4	59.3
	20	320	52.00	41.50				37.8	25.2		38.4	7.4	194.9	60.1
	27	353	51.75	41.00				37.8	25.2		38.4	7.4	194.9	60.1
Mar.	6	364	54.50	40.00				37.8	27.3		39.3	7.5	198.7	60.7
	13	366	52.50	41.00				37.8	28.00		39.6	7.5	200.0	60.9
	20	388	53.00	42.50				37.8	28.0		39.6	7.5	200.0	60.9
	27	397	54.00	41.00				38.5	30.8		41.2	7.7	207.8	62.6
Apr.	3	435	55.75	42.00				38.5	31.5	7.0	46.6	8.2	235.4	64.7
	10	410	55.00	42.00				38.5	31.5	7.0	46.6	8.2	235.4	64.7
	17	437	54.50	41.00				38.5	32.9	7.0	47.1	8.3	238.0	65.1
	24	431	56.00	42.50				38.5	32.9	7.0	47.1	8.3	238.0	65.0
May	1	400	53.00	38.00				39.2	36.4	7.0	49.1	8.5	247.0	67.0

Table XIV

Growth measurements and feed consumption for Guernsey bull no. 15, Group I
Born April 13

Date period ended	Body weight	Heart girth	Height at withers	Herd starter consumed	Alfalfa hay consumed	Milk consumed	Cond. I consumed	Pulp-molasses consumed	Beet pulp consumed	Est. TDN consumed	Total protein consumed	Calcium consumed	Phosphorus consumed
	(lb.)	(in.)	(in.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(gm.)	(gm.)
July 31				28.0	17.9					30.6	5.9	210.2	109.3
Aug. 4	179	39.00	35.25	20.0	17.0					25.7	4.6	183.3	82.8
11	192	38.50	35.25				30.8	5.6		26.2	5.7	131.8	44.9
18	193	39.75	35.75				31.2	6.8		26.0	5.8	135.6	45.8
25	205	39.75	36.00				31.5	7.7		26.6	5.8	138.4	46.5
Sept. 1	213	40.50	36.50				32.2	9.8		27.9	6.0	145.0	48.1
8	220	41.50	35.50				32.9	11.2		29.0	6.2	150.2	49.4
11	221	41.25	37.25				14.1	5.2		12.6	2.7	65.1	21.3
22	226	41.50	37.00				37.3	18.0		35.1	7.1	180.0	57.5
29	246	43.00	37.00				43.0	16.2		32.0	8.1	198.8	65.0
Oct. 6	246	43.25	37.50				34.3	15.4		31.8	6.5	163.4	52.5
13	250	43.75	38.25				34.3	15.4		25.5	6.5	163.4	52.5
24	277	44.25	38.25				55.1	26.2		51.7	10.5	265.1	84.8
31	299	45.00	38.50				35.7	15.4		32.8	6.8	168.9	54.5
Nov. 7	301	45.50	39.50				37.1	22.4		36.8	7.2	187.1	58.4
14	314	46.50	40.00				37.1	22.4		36.8	7.2	187.1	58.4
21	334	46.50	40.50				37.1	25.2		37.9	7.3	192.2	59.1
28	330	47.00	41.25				27.8	28.0		39.6	7.5	160.5	46.8
Dec. 9	310	48.00	41.25				59.4	34.0		58.1	11.5	296.2	92.9
19	352	48.00	41.50				54.0	40.0		56.6	10.7	285.7	86.9
26	355	48.00	41.50				37.6	28.0		39.6	7.5	200.0	60.9

Table XIV (Continued)

Date period ended	Body weight	Heart girth	Height at withers	Hard starter consumed	Alfalfa hay consumed	Milk consumed	Conc. I consumed	Pulp-molasses consumed	Beet pulp consumed	Est. TDN consumed	Total protein consumed	Calcium consumed	Phosphorus consumed
	(lb.)	(in.)	(in.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(gm.)	(gm.)
(1954)													
Jan. 2	371	49.00	41.50				37.8	28.0		39.6	7.5	200.0	60.9
9	380	49.00	41.50				37.8	28.7		39.9	7.5	201.3	61.1
16	385	50.00	42.50				38.5	29.4		40.7	7.7	205.2	62.2
23	380	49.50	43.00				38.5	29.4		40.7	7.7	205.3	62.2
30	385	51.00	43.50				38.5	29.4		40.7	7.7	205.3	62.2
Feb. 6	406	51.00	43.00				38.5	30.8		41.2	7.7	207.8	62.6
13	400	51.00	43.75				38.5	32.9	7.0	47.1	8.3	238.0	65.1
20	405	53.00	42.25				38.5	31.5	7.0	54.5	8.2	235.4	64.7
27	418	52.50	44.00				38.5	32.2	7.0	46.9	8.3	239.7	64.9
March 6	451	53.00	44.25				38.5	34.3	7.0	47.7	8.3	240.5	65.4
13	450	54.00	44.75				39.2	37.8	7.0	49.7	8.5	249.6	67.4
20	490	53.75	44.50				39.2	37.8	7.0	49.7	8.5	249.6	67.3
27	488	54.50	44.00				39.9	42.7	7.0	52.2	8.8	261.2	69.6
April 3	515	55.25	45.00				39.9	44.1	7.0	52.8	8.8	263.8	70.1
10	514	55.50	45.25				39.9	44.1	7.0	52.8	8.8	263.8	70.1
17	537	55.00	45.75				39.9	46.2	7.0	53.6	8.9	267.6	70.6
24	530	56.50	45.50				39.9	49.0	7.0	54.8	8.9	272.6	71.4
May 1	550	56.50	46.00				39.9	49.0	7.0	54.8	8.9	272.6	71.4

Table XV

Growth measurements and feed consumption for Holstein bull no. 21, Group I
Born February 26

Date period ended		Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Herd starter consumed (lb.)	Alfalfa hay consumed (lb.)	Milk consumed (lb.)	Conc. I consumed (lb.)	Pulp-molasses consumed (lb.)	Beet pulp consumed (lb.)	Est. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
March	7	83	29.00	28.50										
	14	94	31.50	30.00	0.5		70				11.8	2.4	39.1	30.3
	21	101	32.25	30.25	0.6	0.6	70				12.2	2.4	44.0	31.3
	28	108	32.75	30.50	2.5	2.3	70				14.5	2.9	62.1	39.3
April	4	115	33.50	30.75	2.8	3.4	63				13.7	2.7	66.2	36.7
	11	122	34.25	31.25	4.7	3.0	50				13.3	2.6	62.3	38.0
	18	129	35.00	31.50	8.0	4.0	42				15.0	3.0	74.0	47.2
	25	136	35.25	32.00	8.8	8.0	28				15.5	3.0	99.8	48.5
May	2	142	36.00	32.25	12.7	9.8					14.8	2.8	106.6	51.5
	9	147	36.50	32.50	17.3	12.6					19.7	3.8	142.8	69.3
	16	153	37.25	33.00	19.5	13.9					22.1	4.2	157.7	77.7
	23	149	37.75	33.25	20.3	25.7					29.0	5.5	252.3	93.6
	30	164	38.50	33.50	21.8	28.3					31.5	6.0	276.4	101.3
June	6	170	39.00	33.75	27.6	23.3					33.2	6.3	261.6	114.1
	13	175	39.75	34.25	33.7	26.7					39.6	7.6	293.5	137.3
	20	181	40.25	34.50	32.5	36.2					43.8	8.3	365.1	154.3
	27	184	40.50	34.75	22.0	29.5					32.3	6.1	288.4	103.3
July	4	187	40.50	35.00	25.0	30.0					34.9	6.6	297.8	113.4
	11	190	40.75	35.00	27.6	22.9					33.1	6.3	249.0	114.3
	18	194	41.00	35.00	31.6	28.0					39.1	7.5	304.0	133.0
	25	198	41.25	35.25	33.8	10.0					30.7	5.9	162.7	118.8

Table XV (Continued)

Date period ended	Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Herd starter consumed (lb.)	Alfalfa hay consumed (lb.)	Milk consumed (lb.)	Conc. I consumed (lb.)	Pulp-molasses consumed (lb.)	Beet pulp consumed (lb.)	Est. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
August 1	200	41.25	35.25	35.0	10.3					31.8	6.1	168.0	122.9
4	203	41.50	35.50	10.0	7.1					11.3	2.2	80.6	39.8
11	217	41.50	35.50				28.1	9.8		24.9	5.3	128.0	42.3
18	237	41.50	35.75				31.7	11.0		28.1	6.0	145.1	47.7
25	246	43.25	36.50				34.3	14.0		31.2	6.5	160.8	52.1
Sept. 1	255	43.75	36.50				34.3	14.7		31.5	6.5	162.1	52.3
8	264	44.50	36.00				35.0	16.8		32.9	6.7	168.7	53.9
11	268	45.75	38.00				15.2	7.4		14.3	2.9	73.4	23.4
22	282	45.25	37.75				46.8	27.5		46.1	9.1	234.6	73.4
29	298	46.50	38.50				36.4	19.6		35.1	7.1	179.0	56.6
Oct. 6	308	47.50	38.75				37.1	22.4		36.0	7.2	187.1	58.4
13	328	47.50	39.00				37.1	24.5		37.6	7.3	190.9	58.9
24	333	48.00	39.00				59.4	27.3		55.3	11.3	284.0	91.1
31	345	49.00	40.25				37.8	28.0		39.6	7.5	200.0	60.9
Nov. 7	355	49.50	40.50				37.8	29.4		40.1	7.5	202.5	61.2
14	370	49.50	41.00				37.8	31.5		41.0	7.6	206.3	61.8
21	396	51.50	41.25				37.8	34.3		42.2	7.7	211.4	62.6
28	402	51.50	42.00				38.5	37.8		44.1	7.9	220.5	64.5
Dec. 9	395	52.00	42.00				66.0	58.5	11.0	73.0	13.3	408.0	111.8
19	418	52.00	42.50				55.0	54.0	10.0	70.9	12.1	352.6	94.8
26	426	52.25	43.75				38.5	37.8	7.0	51.3	8.6	246.8	64.5

Table XV (Continued)

Date period ended	Body weight	Heart girth	Height at withers	Herd starter consumed	Alfalfa hay consumed	Milk consumed	Conc. I consumed	Pulp-molasses consumed	Beet pulp consumed	Est. TDN consumed	Total protein consumed	Calcium consumed	Phosphorus consumed
	(lb.)	(in.)	(in.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(gm.)	(gm.)
(1954)													
Jan. 2	438	53.00	43.00				39.2	37.8	7.0	49.7	8.5	249.6	67.4
9	444	53.50	44.00				39.2	37.8	7.0	49.7	8.5	249.6	67.4
16	475	54.00	44.00				39.2	37.8	7.0	49.7	8.5	249.6	67.4
23	467	54.50	44.00				39.2	39.2	7.0	50.2	8.6	252.1	67.7
30	478	54.50	43.50				39.2	39.2	7.0	50.2	8.6	252.1	67.7
Feb. 6	485	55.00	44.50				39.2	40.6	7.0	50.2	8.6	254.7	68.1
13	502	56.00	44.00				39.9	41.3	7.0	51.6	8.7	232.4	69.3
20	453	55.00	45.00				39.9	44.1	7.0	52.8	8.8	263.8	70.1
27	500	56.00	45.25				39.9	44.1	7.0	52.8	8.8	263.8	70.1
March 6	513	57.75	44.50				39.9	44.8	7.0	53.1	8.8	265.0	70.3
13	535	59.75	45.00				39.9	44.8	7.0	53.1	8.8	265.0	70.3
20	560	57.25	46.00				39.9	49.7	7.0	55.1	9.0	273.9	71.6
27	601	59.50	45.00				39.2	51.8	7.0	55.4	8.9	274.9	71.2
April 3	625	59.50	46.50				40.6	57.4	7.0	58.7	9.3	290.6	72.8
10	635	60.00	46.25				40.6	57.4	7.0	58.7	9.3	290.6	72.8
17	654	60.75	46.50				41.3	62.3	7.0	61.3	9.5	302.2	76.0
24	627	60.50	46.75				41.3	65.1	7.0	62.4	9.6	307.3	77.7
May 1	642	60.75	46.25				41.3	65.1	7.0	62.4	9.6	307.3	77.7

Table XVI

Growth measurements and feed consumption for Ayrshire bull no. 33, Group II
Born September 23

Date period ended	Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Herd starter consumed (lb.)	Prairie hay consumed (lb.)	Milk consumed (lb.)	Conc. II offered (lb.)	Pulp-molasses offered (lb.)	Weigh back (lb.)	Mat. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
Sept. 23	85												
Oct. 6	92	31.75	30.50										
10	96	32.00	30.50	1.5	0.7	40				8.0	1.6	26.5	21.7
17	104	32.50	30.50	3.2	1.7	64				13.7	2.6	45.3	37.8
24	113	33.50	30.50	5.0	3.1	70				16.7	3.1	55.3	47.1
31	123	35.00	31.50	6.1	3.7	63				16.7	3.0	55.2	48.3
Nov. 7	128	35.25	31.25	7.5	5.8	49				16.6	2.8	49.2	48.7
14	145	36.25	32.50	19.3	4.4	42				23.6	4.3	54.6	82.2
21	147	36.75	33.00	21.7	11.2	28				26.6	4.3	87.5	89.7
28	160	37.25	33.50	27.0	15.1					28.6	4.3	93.0	100.8
Dec. 5	165	37.50	33.50	28.0	17.2					29.8	4.4	97.0	103.1
12	182	39.50	33.50	28.0	19.4					30.9	4.4	101.3	105.0
19	192	40.50	34.00	28.0	22.4					32.4	4.5	106.2	107.4
26	205	40.50	34.75	28.0	20.2					31.3	4.4	102.7	105.6
(1954)													
Jan. 2	200	40.50	35.25	28.0	23.3					32.9	4.4	107.7	108.2
9	225	41.50	35.25	28.0	21.3					31.9	4.4	104.4	106.5
16	235	41.50	36.00	28.0	25.6					34.1	4.5	111.5	110.0
23	231	41.50	36.00				33.6	14.0	6.0	26.1	4.6	106.5	15.7
30	236	42.00	36.50				33.6	14.0	7.6	25.1	4.2	101.3	14.8

Table XVI (Continued)

	Date period ended	Body weight	Heart girth	Height at withers	Hard starter consumed	Prairie hay consumed	Milk consumed	Conc. II offered	Pulp-molasses offered	Weigh back	Est. TDN consumed	Total protein consumed	Calcium consumed	Phosphorus consumed
		(lb.)	(in.)	(in.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(gm.)	(gm.)
Feb.	6	237	42.50	37.25				33.6	14.0	7.1	25.4	4.3	102.9	15.1
	16	254	43.25	37.00				45.6	21.0	1.7	40.5	7.8	168.9	25.3
	26	255	43.00	37.00				48.0	20.0	3.8	37.2	6.5	151.4	22.3
March	6	265	41.00	36.50				38.8	16.0	2.6	32.9	6.3	136.6	20.4
	13	265	45.00	37.00				35.7	18.9	5.9	29.7	5.1	122.0	18.0
	20	283	44.00	38.00				35.7	18.9	2.6	31.9	5.8	132.6	19.8
	27	278	44.50	38.00				35.7	19.6	5.1	30.6	5.3	128.8	18.6
April	5	274	45.00	38.50				43.2	17.1	17.3	27.0	3.6	104.4	14.7
	15	295	45.75	37.50				48.0	19.0	11.0	38.9	5.9	142.5	20.8
	24	293	46.00	39.00				46.7	26.2	5.3	41.0	7.2	170.0	25.2
May	1	300	45.00	38.50				37.1	22.4	16.9	25.0	2.8	97.1	13.6

Table XVII

Growth measurements and feed consumption for Ayrshire bull no. 34, Group II
Born September 15

Date period ended	Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Herd starter consumed (lb.)	Prairie hay consumed (lb.)	Milk consumed (lb.)	Conc. II offered (lb.)	Pulp-molasses offered (lb.)	Weigh back (lb.)	Est. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
Sept. 15	80												
Oct. 6	90	30.50	28.25										
10	94	31.50	28.50	1.3	0.8	40				7.9	1.5	26.1	21.2
17	107	32.50	29.00	4.7	2.2	66				15.4	2.9	50.9	43.0
24	110	33.50	29.25	5.3	4.4	63				16.5	2.9	54.4	46.3
31	112	33.00	29.50	6.5	3.2	37				12.5	2.2	41.4	38.5
Nov. 7	112	35.50	30.75	7.5	4.9	42				15.0	2.6	49.4	45.1
14	149	35.00	31.00	21.7	6.9	28				24.4	4.2	80.4	74.7
21	145	35.00	31.25	22.2	11.2					22.4	3.4	73.5	79.8
28	143	36.00	31.75	27.2	13.7					27.4	4.2	90.1	97.7
Dec. 5	155	36.50	31.75	28.0	13.7					28.0	4.3	92.1	100.3
12	163	36.50	31.75	28.0	18.3					30.3	4.4	99.6	104.1
19	171	37.00	32.00	28.0	20.4					31.4	4.4	103.0	105.8
26	178	37.50	32.50	28.0	21.9					32.2	4.4	105.4	107.0
(1954)													
Jan. 2	173	37.75	33.00	28.0	23.6					33.0	4.5	108.2	108.4
9	176	37.75	33.50	28.0	24.8					32.7	4.5	110.1	109.4
16	200	39.00	34.00	28.0	26.3					34.4	4.5	112.6	110.6
23	200	39.00	34.00				32.2	9.8	6.8	22.9	4.0	92.1	13.5
30	207	40.00	34.00				32.2	9.8	8.6	21.7	3.6	86.3	12.5

Table XVII (Continued)

Date period ended	Body weight	Heart girth	Height at withers	Herd starter consumed	Prairie hay consumed	Milk consumed	Conc. II offered	Calf molasses offered	Weigh back	Pat. TMR consumed	Total protein consumed	Calcium consumed	Phosphorus consumed
	(lb.)	(in.)	(in.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(gm.)	(gm.)
Feb. 6	196	40.50	34.00				35.2	11.2	5.1	26.7	5.0	109.1	16.1
16	218	40.75	35.00				44.7	16.0	9.4	32.8	5.7	112.3	19.4
26	206	41.00	34.75				47.6	16.0	11.3	33.6	6.2	134.9	19.6
Mar. 6	210	41.50	34.75				37.6	12.8	9.0	38.3	4.5	106.6	16.5
13	216	41.25	34.50				32.9	11.2	7.8	23.3	4.0	93.5	13.6
20	220	41.25	34.50				32.9	12.6	17.9	17.6	1.6	63.5	8.5
27	220	41.25	35.00				33.6	12.6	9.3	23.4	3.8	93.3	13.5
April 5	219	41.50	35.25				42.2	16.2	11.3	29.8	4.8	119.1	17.3
15	219	42.25	35.50				48.0	18.0	25.5	25.5	2.5	94.0	12.7
24	221	42.00	36.00				41.2	16.2	20.3	23.2	2.5	87.1	12.0
May 1	230	42.00	35.00				33.6	12.6	17.6	18.0	1.8	66.6	9.0

Table XVIII

Growth measurements and feed consumption for Ayrshire bull no. 35, Group II
Born September 12

Date period ended	Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Herd starter consumed (lb.)	Prairie hay consumed (lb.)	Milk consumed (lb.)	Conc. II offered (lb.)	Pulp-molasses offered (lb.)	Weigh back (lb.)	Mat. DM consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
Sept. 12	65												
Oct. 6	82	30.00	28.00										
10	86	31.50	28.25	1.0	0.5	36				6.9	1.4	22.8	18.4
17	95	32.00	28.50	4.4	2.0	63				14.6	2.8	48.2	41.5
24	104	33.00	29.00	4.1	5.0	63				15.9	2.8	52.4	43.0
31	115	34.00	29.50	5.0	3.5	41				12.2	2.1	40.3	35.6
Nov. 7	118	34.00	29.75	7.5	4.1	28				12.0	2.1	40.5	38.7
14	129	34.25	30.50	18.6	5.7					16.8	2.8	55.6	63.8
21	132	36.00	30.75	20.3	12.0					21.4	3.2	70.1	74.4
28	131	35.75	31.00	27.6	14.2					27.9	3.4	91.9	99.4
Dec. 5	145	36.00	31.50	20.0	16.0					29.2	4.3	95.8	102.2
12	160	37.00	32.00	28.0	18.8					30.6	4.4	100.4	104.5
19	173	37.75	32.25	28.0	20.1					31.3	4.4	102.5	105.5
26	186	38.50	32.50	28.0	19.8					31.1	4.4	102.0	105.3
(1954)													
Jan. 2	181	38.50	33.50	28.0	22.8					33.4	4.5	106.8	107.7
9	195	39.25	34.00	28.00	24.4					34.1	4.5	109.5	109.1
16	205	40.50	35.00	28.0	25.6					34.1	4.5	111.5	110.0
23	208	41.50	34.50				32.2	9.8	5.9	23.5	4.2	95.0	14.0
30	207	41.00	34.50				33.7	10.5	4.2	26.0	4.9	106.3	15.7

Table XVIII (Continued)

Date period ended	Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Hard starter consumed (lb.)	Prairie hay consumed (lb.)	Milk consumed (lb.)	Conc. II offered (lb.)	Pulp-molasses offered (lb.)	Weigh back (lb.)	Est. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
Feb. 6	200	42.50	34.75				35.2	11.2	1.2	29.3	5.9	121.7	18.2
16	218	42.25	35.00				47.0	16.0	8.3	35.1	6.3	142.8	21.0
26	208	43.50	35.25				47.0	16.0	37.6	16.1	-0.6	48.4	5.2
March 6	217	42.50	35.25				37.6	12.8	16.8	21.5	2.7	81.5	11.3
13	216	42.50	35.50				32.9	12.6	23.3	13.3	0.3	46.2	5.6
20	230	42.50	35.75				32.9	12.6	20.9	15.4	0.9	53.9	6.9
27	230	43.00	36.00				33.6	13.3	10.0	23.2	3.6	92.3	13.3
April 5	230	45.00	36.25				43.2	17.1	12.8	29.9	4.6	118.9	17.2
15	242	45.00	35.25				48.0	19.0	28.3	24.1	1.9	86.8	11.5
24	232	43.75	36.50				43.9	18.5	17.2	20.9	3.8	109.4	15.5
May 1	234	43.50	36.00				33.6	14.7	13.5	18.3	1.6	67.5	9.1

Table XIX

Growth measurements and feed consumption for Ayrshire bull no. 36, Group II
Born September 19

Date period ended	Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Hero starter consumed (lb.)	Prairie hay consumed (lb.)	Milk consumed (lb.)	Cane, II offered (lb.)	Pulp-molasses offered (lb.)	Welch back (lb.)	Est. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
Sept. 19	75												
Oct. 6	84	30.00	28.00										
10	89	30.25	28.50	1.3	0.7	40				7.9	1.5	26.6	21.1
17	95	31.00	29.00	3.0	1.8	65				15.3	2.9	50.5	44.0
24	98	31.50	30.25	4.0	2.1	63				14.3	2.7	47.4	40.3
31	101	31.50	29.75	3.9	3.6	49				12.8	2.3	42.0	35.4
Nov. 7	106	33.00	28.75	4.9	4.0	40				12.2	2.1	40.3	35.3
14	117	33.00	29.25	16.1	8.8	11				16.8	2.8	55.5	60.5
21	117	33.00	29.25	19.1	8.3					16.6	2.9	61.1	67.5
28	123	33.00	29.00	27.2	13.9					27.5	4.2	90.4	97.9
Dec. 5	130	33.50	29.50	28.0	17.1					29.7	4.4	97.6	103.1
12	135	34.00	29.00	28.0	19.1					30.7	4.4	100.9	104.7
19	146	35.00	29.75	28.0	20.9					31.7	4.4	103.8	106.2
26	158	36.25	30.50	28.0	21.6					32.0	4.4	104.9	106.8
(1954)													
Jan. 2	159	36.25	31.00	28.0	23.2					32.8	4.5	107.5	108.1
9	170	36.50	31.00	28.0	24.5					33.5	4.5	109.7	109.1
16	177	38.00	32.00	28.0	26.5					34.5	4.5	112.9	110.8
23	188	37.75	32.00				30.8	9.8	4.3	23.5	4.4	96.0	14.2
30	189	39.00	32.50				32.4	9.8	3.4	25.2	4.9	103.7	15.4

Table XIX (Continued)

Date period ended	Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Hand starter consumed (lb.)	Prairie hay consumed (lb.)	Milk consumed (lb.)	Conc. MI offered (lb.)	Pulp-molasses offered (lb.)	Beet tops offered (lb.)	Est. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
Feb. 6	189	40.00	32.50				34.5	9.8	2.5	27.3	5.4	112.9	16.8
16	197	39.50	33.00				43.7	14.7	9.6	31.4	5.4	126.4	18.5
26	198	40.00	33.25				46.0	14.0	10.9	31.9	5.5	127.8	18.6
March 6	207	40.25	33.50				36.0	11.2	7.4	26.4	4.7	106.5	15.6
13	200	41.00	33.75				32.9	11.2	9.3	22.3	3.2	88.7	12.8
20	210	40.00	34.00				32.9	11.2	10.9	21.3	3.2	83.5	11.9
27	204	40.00	33.75				32.9	11.2	13.5	19.6	2.6	75.2	10.5
April 5	198	40.25	33.50				43.1	14.2	12.5	28.9	4.6	114.3	16.5
15	215	40.25	33.00				47.0	16.0	31.5	20.1	0.9	68.1	8.5
24	208	40.50	34.50				42.3	15.8	12.9	28.7	4.4	113.5	16.3
May 1	219	40.50	34.00				33.6	12.6	23.8	14.0	0.4	46.6	5.7

Table XX

Growth measurements and feed consumption for Ayrshire bull no. 37, Group II
Born September 23

Date period ended		Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Herd starter consumed (lb.)	Prairie hay consumed (lb.)	Milk consumed (lb.)	Conc. II offered (lb.)	Pulp-molasses offered (lb.)	Weigh back (lb.)	Nat. HAN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
Sept.	23	85												
Oct.	6	89	30.25	29.25										
	10	95	31.00	29.75	1.4	0.5	32				6.5	1.3	21.6	18.0
	17	106	32.25	30.00	4.6	1.4	67				14.6	2.8	48.4	41.3
	24	118	33.50	30.50	4.0	3.8	70				16.4	3.0	54.0	44.5
	31	126	34.50	30.75	6.3	4.3	63				17.2	3.1	56.7	49.4
Nov.	7	130	35.25	32.00	6.9	4.5	49				15.5	2.7	51.0	45.7
	14	150	36.00	32.00	22.3	5.6	35				25.3	4.5	83.6	89.9
	21	145	36.50	32.00	22.5	11.3	28				28.2	4.4	89.6	92.3
	28	151	37.00	32.00	28.0	13.6					27.9	4.3	91.9	100.2
Dec.	5	160	38.00	32.75	28.0	6.6					24.4	4.2	80.5	94.5
	12	165	38.25	33.00	28.0	18.5					30.4	4.4	99.9	104.2
	19	180	38.50	33.50	28.0	20.8					31.6	4.4	103.6	106.1
	26	194	39.00	34.00	28.0	20.7					31.6	4.4	103.5	106.1
(1954)														
Jan.	2	190	39.50	34.00	28.0	23.1					32.8	4.5	107.4	108.0
	9	200	39.50	34.50	28.0	24.5					33.0	4.5	109.7	109.1
	16	214	40.50	34.75	28.0	25.7					33.0	4.5	111.6	110.1
	23	220	41.25	35.50				32.9	10.5	3.4	25.9	5.0	106.4	15.8
	30	227	41.75	35.50				33.6	12.6	7.8	24.4	4.1	98.2	14.3

Table XI (Continued)

Date period ended	Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Hard starter consumed (lb.)	Prairie hay consumed (lb.)	Silk consumed (lb.)	Conc. II offered (lb.)	Pulp, molasses offered (lb.)	Weigh back (lb.)	Est. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
Feb. 6	230	42.50	35.00				36.0	11.2	5.1	27.3	5.1	111.5	16.5
16	230	42.00	35.00				45.6	16.6	2.4	38.3	7.5	159.0	23.6
26	234	42.50	35.75				48.0	16.0	3.6	38.9	7.6	160.9	24.0
March 6	245	43.50	36.00				38.4	12.6	1.3	32.2	6.4	133.8	20.0
13	245	44.50	36.25				35.0	16.1	0.8	31.4	6.1	131.2	19.7
20	255	44.50	36.00				35.0	16.6	2.8	30.4	5.6	126.0	18.8
27	253	44.50	36.25				35.0	16.1	0.7	26.3	4.2	105.8	15.4
April 5	250	44.25	36.50				45.0	20.7	15.7	30.8	4.4	121.5	17.4
15	269	45.50	36.75				50.0	23.0	24.3	29.8	3.2	112.9	15.6
24	264	44.75	37.00				45.7	23.5	16.7	31.8	4.3	125.4	17.9
May 1	270	46.00	38.00				35.7	18.9	7.2	28.9	4.8	117.8	17.3

Table XXI

Growth measurements and food consumption for Ayrshire bull no. 38, Group II
Born September 10

Date period ended	Body weight (lb.)	Heart girth (in.)	Height at withers (in.)	Hard starter consumed (lb.)	Prairie hay consumed (lb.)	Milk consumed (lb.)	Conc. II offered (lb.)	Pulp-molasses offered (lb.)	Neigh back (lb.)	Wat. TDN consumed (lb.)	Total protein consumed (lb.)	Calcium consumed (gm.)	Phosphorus consumed (gm.)
Sept. 10	85												
Oct. 6	100	31.75	30.00										
10	102	32.00	30.00	1.4	1.2	36				7.5	1.4	24.9	20.2
17	106	32.50	30.25	3.8	1.9	55				12.0	2.4	42.3	36.2
24	112	33.75	30.50	4.9	3.1	49				13.3	2.4	43.7	38.2
31	134	34.50	30.75	6.9	4.4	42				14.3	2.5	47.0	42.6
Nov. 7	135	35.50	30.75	8.6	5.4	28				13.8	2.3	45.3	43.3
14	150	36.00	31.75	21.0	5.1					18.4	3.1	60.6	71.0
21	155	36.00	32.50	24.3	12.4					24.6	3.7	80.7	87.4
28	165	37.00	32.50	27.8	15.1					28.6	4.3	93.8	100.8
Dec. 5	170	37.50	33.00	28.0	15.4					28.9	4.3	94.8	101.7
12	181	38.75	33.00	28.0	18.8					30.6	4.4	100.4	104.5
19	191	39.00	33.50	28.0	20.0					31.2	4.4	102.3	105.4
26	200	39.25	33.75	28.0	19.8					31.1	4.4	102.0	105.3
(1954)													
Jan. 2	200	40.00	34.50	28.0	24.5					33.5	4.5	109.7	109.1
9	213	40.00	34.50	28.0	24.9					33.7	4.5	110.3	109.4
16	220	41.00	35.50	28.0	27.2					34.9	4.5	114.1	111.3
23	224	41.75	35.50				32.9	12.6	3.9	26.4	4.9	108.6	16.1
30	239	42.50	35.75				33.6	12.6	0.3	24.1	7.9	96.5	14.0

Table XXI (Continued)

Date period ended	Body weight	Heart girth	Height at withers	Hard starter consumed	Prairie hay consumed	Milk consumed	Conc. II offered	Pulp-molasses offered	Weigh back	Est. TDN consumed	Total protein consumed	Calcium consumed	Phosphorus consumed
	(lb.)	(in.)	(in.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(lb.)	(gm.)	(gm.)
Feb. 6	228	43.25	35.75				36.8	14.0	2.7	30.6	5.9	126.7	18.9
16	227	42.50	36.00				46.5	21.0	5.0	39.0	7.1	161.8	23.9
26	251	43.50	36.75				49.0	20.0	7.3	38.9	7.0	159.2	23.5
March 6	247	44.00	36.25				39.9	18.1	4.0	33.7	6.2	139.2	20.7
13	247	44.00	37.00				35.0	16.1	3.8	29.4	5.4	121.6	18.1
20	264	45.00	37.00				35.0	16.8	4.2	29.5	5.3	121.5	18.0
27	264	45.50	37.75				35.0	17.5	4.4	29.6	5.3	122.2	18.1
April 5	265	46.50	38.50				45.0	22.5	24.4	25.9	2.4	96.7	13.2
15	278	46.00	37.50				50.0	25.0	22.5	31.8	3.7	122.3	17.1
24	265	45.75	38.00				47.6	24.4	20.7	31.0	3.7	119.8	16.8
May 1	274	46.00	39.00				45.7	23.9	17.0	31.8	4.3	125.2	17.8

VITA

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Master of Science

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THESIS TITLE: EXPERIMENTAL RATIONS TO STUDY THE PHOSPHORUS REQUIREMENT OF YOUNG DAIRY BULLS FOR GROWTH AND REPRODUCTION

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