PROTEIN REQUIREMENTS OF DAIRY CALVES: NITROGEN RETENTION AS RELATED TO LIVE WEIGHT AND AGE

By

JACK L. GRIFFITH

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Thesis Approved:

Magnar Ronning
Thesis Adviser

O. L. Norton
Faculty Representative

Robert MacVicar
Dean of the Graduate School

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INTRODUCTION

Recommended nutrient allowances for young dairy calves are based upon relatively few data. Current standards are based upon bodyweight with no consideration being given to the age of the animal.

Growth characteristically occurs at a rapid rate at an early age and gradually declines until maturity is reached. It seems clear that a nutrient requirement of a young animal must not only be considered in relation to its bodyweight but also its age, since the rate of growth is a function of time.

Morrison's 1948 standard protein allowance for calves is based upon relatively few experiments (38). Apparently only one of these experiments involved calves with initial weights of less than 200 lb. (44). The allowance of digestible protein for young dairy calves currently recommended by the National Research Council (27) represents the amounts generally consumed when whole milk is fed.

This study of nitrogen retention and digestibility with eight young dairy calves at different ages was made in an effort to collect more sound data from which to propose a standard allowance.

REVIEW OF LITERATURE

The Armsby standard (2) for digestible true protein has been found to be too liberal by some investigators (50) while others (6) found that it underestimates the protein requirement. Mitchell's standard (34) is apparently based upon a sound procedure except that in this estimate no provision was made for the metabolic fecal nitrogen loss and at that time enough experimental data were not available on the different constituents of the protein requirement and the factors which affect them. Morrison's 1936 standard (37) was based primarily upon experiments as summarized by Armsby (3) and Forbes (19). Morrison's revised standard (38) approximates the current standard of the National Research Council (27).

Lofgreen (26) found there was no advantage in supplying more protein to Holstein calves from 150 to 350 lb. bodyweight than that recommended in the 1936 Morrison standard. An intake somewhat below the lower limit of this standard produced as good gains as did higher levels. The data showed Morrison's standard to be liberal for calves weighing from 600 to 1,000 lb. He concluded that Mitchell's 1929 estimate (34) for digestible protein was grossly inadequate for heifers weighing over 700 lb.

In a feeding trial with dairy calves from 8 to 16 weeks of age, Harris and Loosli (20) found that a ration containing 18.8 per cent crude protein and balanced in energy, fat, calcium and phosphorus produced growth slightly above Ragsdale's standard. Rations containing 15.2 and 11.7 per cent crude protein produced gains slightly below normal while 8.3 per cent crude protein produced poor growth. About the same amounts of nitrogen were stored on diets containing 15.2 and 18.8 per cent crude protein whereas appreciably lower amounts were stored on diets containing 11.7 and 8.3 per cent.

Lofgreen et al. (24) fed Holstein calves two levels of digestible crude protein and total digestible nutrients. The lowest levels were equivalent to Morrison's 1936 standard while the higher energy level was increased by 20 per cent and the higher protein level by 60 per cent.

A 20 per cent increase in energy brought about a significant difference in nitrogen retained per day when the calves were on the low protein intake. No increase in nitrogen retention was observed when calves which were on the high protein level received additional energy. The average daily gain in bodyweight of the calves was 1.2 lb. in the low energy groups and 1.4 lb. in the high energy groups, but there was no significant difference between the low or high protein intake.

Humble (21) conducted a feeding trial with dairy calves in which 6 calves each in 3 groups were fed starters containing 15.31, 17.88 and 20.75 per cent total protein. The protein intakes of the three groups were 85.0, 100.0 and 115.0 per cent of Morrison's 1948 minimum allowance, respectively. The T.D.N. intakes were calculated to be the minimum allowance and equal in all groups in order that differences in response of the protein levels could be better observed. At the end of 16 weeks all three groups were below Ragsdale's standard with respect to live weight. More efficient utilization of protein appeared to be associated with the lower protein intakes. There was no advantage of feeding calves protein calculated to be above Morrison's minimum protein allowance.

Mitchell's 1929 standard (34) was calculated by a factorial procedure by determining separately the different components of the total requirement and their variations with age, breed, sex and functional activity of the animal. It has been improved upon by several investigators since its establishment. In the calculation of this standard there was no consideration given for metabolic fecal nitrogen.

Blaxter and Price (7) fed sixteen dairy Shorthorn heifers according to Mitchell's standard (34) and obtained poor growth. The addition of 0.5 lb. of starch did not improve the growth rate. The addition of 0.5 lb. of protein improved growth but the addition of 0.25 lb. of protein and 0.25 lb. of starch was equally effective.

Blaxter and Mitchell (6) recalculated Mitchell's factorial method to include the metabolic fecal nitrogen which may represent 20 to 70 per cent of the requirement of the ruminant for metabolizable protein, depending on age.

Trimberger and Davis (53) demonstrated normal growth with Holstein calves when either tankage, dried whey and blood meal, dried skim milk powder, or blood meal was the principal source of protein and fed at the rate of approximately 15.88 per cent digestible protein with 73 - 75 per cent T.D.N. Soybean meal and ground soybeans were not satisfactory as the principle source of protein in a dry calf starter for calves of approximately one month of age.

Norton and Eaton (42) found that a dry calf starter consisting of 16 - 18 per cent of soybean oil meal gave good results. Calves which were fed by a limited whole-milk and dry-calf-starter method were able to make satisfactory growth on starters which contained no animal protein.

Swett *et al.* (50) found Armsby's standard to be from 50 to 60 per cent higher than necessary for promotion of normal growth of Holstein and Jersey calves. On the average all calves were able to make normal growth when receiving a protein level of 64.4 per cent of the standard. However, Armsby's standard failed to make sufficient allowances for advances in age.

Robinson (45) obtained about as satisfactory gains with mixtures containing either 12.0 or 16.0 per cent digestible protein. Daily gains were 1.41 lb. for the high protein as compared to 1.36 lb. with the low protein group.

Ritzman and Colovos (44) found that the efficiency of utilization of digestible protein was variable among Holstein heifer calves. The efficiency of utilization of digestible protein was highest during the first month of life and declined until four months of age.

Blaxter and Wood (8) found with three Ayrshire calves that the apparent digestibility of the dry matter dropped from 94 to 77 per cent when they were switched from a dried-milk-protein diet to a nitrogen-free diet. This was associated with a decrease from 91.7 to 44.9 per cent in the apparent digestibility of the dietary fat and a decrease in the digestibility of the energy of the diet from 92.9 to 66.5 per cent.

Perkins and Monroe (43) observed that the digestibility of each ingredient of the ration as determined by trial was lower than that calculated by the use of average digestion coefficients. Their experiment involved three balance trials with four cows receiving rations with large excesses of protein and four trials with four cows receiving rations decidely deficient in protein. These differences were greater in the case of the low protein ration than in the high protein ration.

Metabolic fecal nitrogen appears in the feces incidental to nitrogen intake. Evidently this fecal nitrogen can be attributed to the maintenance of highly active mucosal cells of the intestine and to the enzymatic secretions during the work of digestion. The metabolic fecal nitrogen in ruminant animals has been found to be nearly five times as great per 100 g. food consumed as that found in non-ruminant animals. This difference might be attributed to the higher fiber intake. Blaxter and Mitchell (6) found the metabolic fecal nitrogen to be approximately 0.5 g. per 100 g. of dry matter consumed in the adult ruminant.

Blaxter and Wood (8) found that the nitrogen content of the feces of three Ayrshire calves receiving a nitrogen-free diet was 0.427 $\pm$ 0.013 g. per 100 g. of dry matter ingested. These data suggest that metabolic fecal nitrogen excretion is influenced by the quantity of dry feces excreted per day rather than the dry matter intake.

Lofgreen and Kleiber (23) determined the metabolic fecal nitrogen excretion of four young dairy calves by feeding casein labeled with radioactive phosphorus (P^{32}) incorporated into a purified liquid diet. The average metabolic fecal nitrogen excretion was 0.27 g. per 100 g. dry matter intake. The true digestibility of the nitrogen of the casein averaged 93.5 per cent.

Blaxter and Mitchell (6) found that in the rat and pig the metabolic fecal nitrogen is related to the mass of the body, ($W^{3/4}$ or M^2 of body surface), but at maintenance and supermaintenance levels of feeding, the output of metabolic fecal nitrogen is related to the composition of dry matter for rations of similar composition.

Mitchell and Bert (35) showed that in rats the ratio of metabolic fecal nitrogen to air-dried food consumed was linearly related to the protein content of diets ranging from 0.26 to 20.0 per cent. It appeared that the direct determination of the metabolic fecal nitrogen per unit of dry food consumed was a valid method for the growing rat.

Schneider (47) in an extensive review of metabolic fecal nitrogen with rats found that the metabolic fecal nitrogen consists of two fractions: one related to the bodyweight and the other to the intake of dry food. The ratio of metabolic fecal nitrogen to the intake of dry food assumed practically a constant level for intakes of food above a certain minimum value, which seemed to approximate that required for maintenance of bodyweight in the case of the usual low-nitrogen diets used in protein evaluation work.

Bosshardt and Barnes (10) found the metabolic fecal nitrogen to be 323 mg. per 100 g. food consumed with mice on a diet in which the caloric content was restricted to 30 per cent of the requirement. When fed ad lib the metabolic fecal nitrogen values found by extrapolation were 221 mg. per 100 g. of food consumed for whole egg and 217 mg. per 100 g. of food consumed for wheat gluten. The digestibility of the protein increased when the protein intake was restricted. These data indicate that metabolic fecal nitrogen values determined with protein-free or low protein diets are not reliable indices of the metabolic fecal nitrogen.

Urinary nitrogen excretion of growing animals consists of two fractions: the endogenous nitrogen which is an end product of body protein catabolism and exogenous nitrogen which represents the amount of nitrogen intake above that required for maintenance and used for growth.

According to Brody (11) the urinary nitrogen excreted by an animal on a minimum nitrogen ration which would support normal growth might be considered as the basal nitrogen metabolism.

Blaxter and Wood (8) found that the endogenous urinary nitrogen of three Ayrshire calves on a nitrogen free diet was 81.9 mg. per day per kg. bodyweight. The basal energy metabolism was 43.1 Cal. per kg. per day. The amount of endogenous nitrogen excreted per Calorie of basal heat produced was 1.90 mg. $\pm$ 0.068.

Smuts and Maraic (49) found 2.0 mg. endogenous nitrogen were excreted per Calorie of basal heat production in sheep.

Ashworth (5) found that weanling rats excreted less than 1 mg. endogenous urinary nitrogen per Calorie during basal metabolism and that adult rats excreted about 1.5 mg. as determined on a nitrogen-poor diet. On a nitrogen-free diet rats weighing over 100 g. which had been on a high protein diet excreted 26 per cent more nitrogen and produced 7.6 per cent less basal heat per unit of bodyweight than their litter mates which had been on a low protein diet. This suggested that endogenous nitrogen followed more closely a logarithmic function of bodyweight than a logarithmic function of basal heat production.

The endogenous catabolism of nitrogen apparently is in part controlled by hormonal influences as well as the level of dietary intake of protein and energy.

Mukherjee and Mitchell (32) found the basal metabolism in hyperthyrodism was increased by 31 and 35 per cent and the minimum endogenous urinary nitrogen by 19 and 16 per cent respectively in two Holstein bulls.

Kleiner (22) found that the administration of cortical hormones to a fasting animal increased the rate of protein breakdown. Brody (12) found that on administration of an excess of cortin or adrenotropic hormone there was an increase in the catabolic rate, especially of protein deamination and urinary nitrogen excretion. The excessive deamination was associated with excess sugar formation and excretion.

The nitrogen balance of animals has been shown to be affected by changes in the energy intake (4, 6, 14, 15, 24, 26, 39, 40, 46, 48 and 53). Carbohydrates have more immediate effects than fats in their sparing action on protein (15, 29, 39, 40, 48 and 51). The time of feeding of carbohydrates and fats in relation to the time of feeding of protein influenced the degree of the protein sparing effect of these materials in the case of simple stomached animals (29, 39, 40 and 51).

Bosshardt (9) found that the level of intake exhibiting maximal protein utilization coincided with a maximal caloric intake per unit of body surface area in rats and mice. There was some indication that there may be a limit to which additional non-protein calories can enhance growth utilization of protein.

Armsby and Moulton (3) found that while a surplus of protein in the ration stimulated total storage of protein by the animal, the efficiency of utilization of dietary protein was reduced. Optimum efficiency was observed only when dietary protein was limited to the minimum of the particular protein in question which was necessary to support normal growth.

Forbes et al. (19) found that calves which were fed a higher protein level had slightly greater gains than calves on lower protein intakes, but the utilization of protein was greatest at the lower protein intakes. The energy levels in this study were higher than those recommended in Morrison's 1948 standard.

Calloway (13, 14 and 15) working with low protein intakes found that when caloric intake was restricted, an increase in protein intake decreased nitrogen output. The degree of nitrogen balance was directly proportional to the caloric intake and amount of nitrogen fed during standardization.

Nevens et al. (41) found that an excess of protein apparently tended to diminish the average daily gain of bodyweight per 1,000 lb. bodyweight in dairy heifers.

Wise et al. (55) observed higher blood plasma nitrogen levels in calves receiving a protein-supplemented ration as compared to calves receiving a sugar-supplemented ration.

Mitchell et al. (36) found that utilization of the metabolizable energy in the ration of growing calves was not impaired by levels of protein from 6.0 to 20.0 per cent. Nitrogen balances increased with increasing percentage of protein. The additon of glucose decreased the digestibility of insoluble carbohydrates.

Fontenot (18) found the addition of 350, 700 and 1,050 g. cerelose to an 8 per cent protein ration for Hereford steers resulted in a significant depression in nitrogen retention. The addition of 700 and 1,050 g. to a 10 and 12 per cent protein ration resulted in a significant increase in nitrogen retention. However, in each experiment the increase in fecal nitrogen was roughly proportional to the amount of cerelose added.

According to experiments by Schreiber and Elvehjem (48), the use of high-fat or high-protein diets or both under conditions of water restriction was responsible for larger weight losses than occurred with high carbohydrate diets.

Conrad and Hibbs (16) found that cud inoculations increased the apparent digestibility of protein by a calf when low protein, poor quality hay was fed, but this was not shown with good quality alfalfa hay. Nitrogen retention was not significantly affected by rumen inoculations.

Tillman and MacVicar (52) found that a level of 11.8 mg. of chlortetracycline per 100 lb. bodyweight had no effect upon the ration digestibility of sheep. When 15.4 mg. per 100 lb. of bodyweight was fed, there was a significant reduction in digestibility of dry matter, crude protein, crude fiber, nitrogen-free extract and energy. Neither level had any effect upon nitrogen retention.

McDonald (30) found that ammonia was the main component of the non-protein nitrogen in the rumen fluid when the animal was fed natural diets or a diet in which casein was the main source of nitrogen.

Agrawala et al. (1) found with fistulated animals that appreciable synthesis of protein from urea in the bovine rumen occurred within 6 hours after feeding. In 7 trials, the amount of "true" protein synthesized varied from 33 to 109 g.

Loosli et al. (28) found 9 - 20 times as much of the 10 essential amino acids, except isolucine, in the rumen material of lambs as was in the diet which was free of protein but contained urea as the main source of nitrogen. The lambs were in positive nitrogen balance and gained an average of 0.23 lb. daily.

Duncan et al. (17) obtained evidence that rumen microorganisms of the calf could utilize urea nitrogen to synthesize amino acids. With the exception of histidine, the amino acid pattern of the mixed protein of ingesta of fistulated calves on purified rations was fundamentally similar to that found with a calf on a natural ration.

Lofgreen et al. (25) found that the addition of 0.2 per cent methionine to a ration containing 10 per cent protein with urea furnishing 40 per cent of the total nitrogen significantly increased the nitrogen retention of lambs.

Wegner et al. (54) found that when the level of protein in the concentrate fed was increased to more than 18 per cent, the rate and extent of conversion of added urea nitrogen to protein began to decrease. When no linseed oil meal was added to a basal grain mixture containing 11.3 per cent protein, added urea was utilized up to the level of 4.5 per cent of the grain mixture. This mixture contained a protein equivalent of 12 per cent and the rate of conversion of urea nitrogen to protein in the rumen decreased as further additions of urea increased the protein level of the rumen ingesta above 12 per cent.

According to McNaught and Smith (31) the utilization of non-protein-nitrogen was detectable only when protein synthesis exceeded protein degradation by rumen bacteria. Since bacterial protein is of higher nutritive value, biological values as determined for non-ruminants are of little significance in the ruminant.

EXPERIMENTAL

The purpose of this study was to gain further knowledge concerning the protein requirements of young dairy calves. This experiment was a preliminary effort to investigate possible relationships between nitrogen retention, live weight and rate of live weight at various ages.

Eight male calves consisting of two Holsteins, three Guernseys, two Ayrshires and one Jersey were obtained for this study. Live weight and other information about each calf at birth is given in Table I.

The calves were removed from their dams at two days of age and placed in individual tie stalls. Feed was offered twice daily and water was before them at all times.

The calves were placed on three different dietary regimes at selected ages during this experiment. They were placed on a whole-milk diet after being removed from their dams. Later a whole milk and grain ration was fed and finally a ration made up of grain and prairie hay was offered. Two metabolism trials were conducted with each calf on each ration. In case a calf was not in condition to start a metabolism trial on schedule, the trial was omitted and preparations were made for the next planned trial.

The amount of feed supplied throughout the experiment was calculated to conform to Morrison's 1948 minimum allowance for D.P and T.D.N. Adjustments in the amounts supplied were made at weekly intervals according to live weight of each calf.

TABLE 1

BIRTH DATA OF EIGHT MALE DAIRY CALVES

Calf	Weight at birth	Tattoo	Date of Birth
	lb.	no.	
H 21	95	178	9/ 4/55
H 59	100	148	10/19/55
G 88	55	145	9/ 8/55
G 143	70	146	9/18/55
G 112	75	148	10/17/55
J 63	65	195	11/14/55
A 43	70	156	10/21/55
A 49	50	154	10/ 3/55

The schedule for the metabolism trials was evenly distributed with respect to the age of the calves with collection periods planned to begin at 9, 30, 51, 72, 93 and 114 days of age. However, some deviations from this schedule were necessary to allow sufficient time for standardizing the intake levels after cases of sickness.

Trials I through IV involved three-day preliminary and five-day collection periods while in trials V and VI, four-day preliminary periods preceded seven days of collection.

Measurements of live weight, height at withers and chest circumference were made on three consecutive days before the calves were placed in the metabolism stalls and on three consecutive days after being removed from the stalls at the end of each trial. Similar measurements were made weekly during the intervals between the metabolism trials.

The calves were fed, and feces and urine were collected twice daily at twelve hour intervals during the trials. Feed refusals were collected daily. Upon completion of the trial representative samples of the feeds and feed refusals were taken for analyses.

Daily aliquots of 10 per cent of the wet feces voided were composited and preserved with thymol crystals and stored under refrigeration in sealed jars. Upon completion of the collection periods, the aliquots were removed from the jars, thoroughly mixed and representative samples taken for analyses.

Urine was diluted with water to a constant volume twice daily and one per cent was taken as a sample of the collection. Loss of ammonia was prevented by the addition of enough hydrochloric acid to render the urine slightly acid immediately as it was voided into the collection bottle.

Upon completion of each collection period with each calf the feed, feces and urine samples were taken to the Agricultural Chemistry Department for appropriate analyses. Nitrogen, fiber, ether extract and nitrogen-free-extract of the feeds and feces and nitrogen of the urine were determined by standard A.O.A.C. methods of analysis (56). Butter fat of the milk was determined by the Babcock method (56) while the dry matter (total solids) was determined by the Cenco method (58). The results of all analyses are reported in appendix tables I through VII.

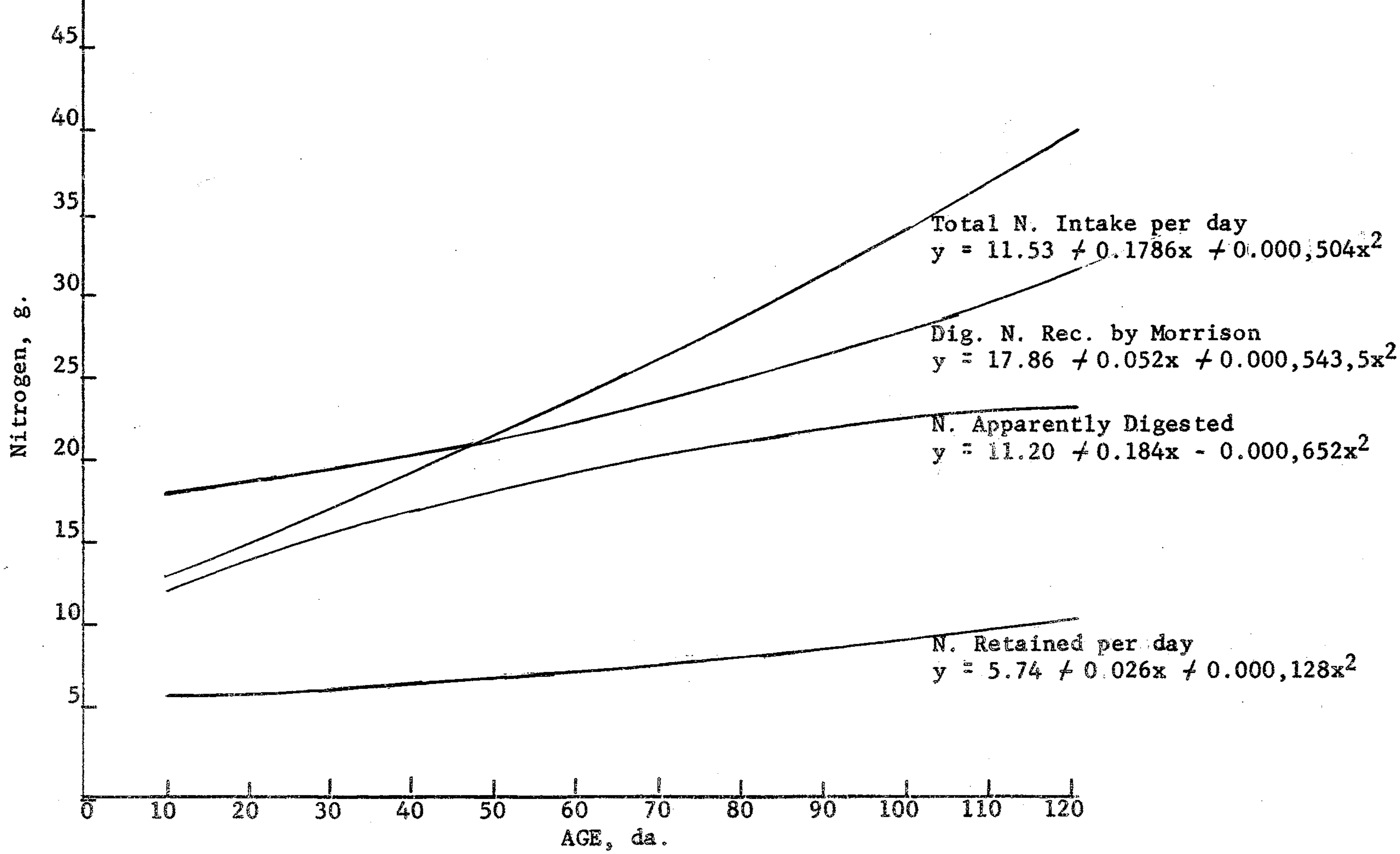
RESULTS AND DISCUSSION

A total of 38 nitrogen retention trials were completed in this experiment. The average amounts of nitrogen retained, consumed and apparently digested per day are shown graphically in fig. 1. The intake of apparently digested nitrogen never reached Morrison's recommended level as shown. The apparent digestible nitrogen intake approached the recommended standard most closely when urinary nitrogen excretion was at a maximum.

The average daily retention of nitrogen increased gradually from 5.74 g. at birth to 9.62 g. at 100 days of age as shown graphically in figs. 1 and 2 and by tabulation in Table 2. There was some variability among individual calves, between trials with respect to the amount of nitrogen retained as shown in appendix Table IX. A small negative nitrogen retention was recorded in trial I of Guernsey No. 112. This apparently was caused by a digestive disturbance during this trial. The other trials with this calf appeared to be normal in every respect.

The average daily retention of nitrogen and gain in live weight in relation to age is shown graphically in fig. 2. The curve fitted to daily nitrogen retention did not parallel the curve fitted to the average daily gain in live weight. The apparent lack of relationship between the two curves suggests the degree of deception which may be encountered when daily gain in live weight is used as the basis for estimating net gain in body tissue (true growth).

Figure 1. Average Nitrogen Consumed, Digested and Retained per Day.



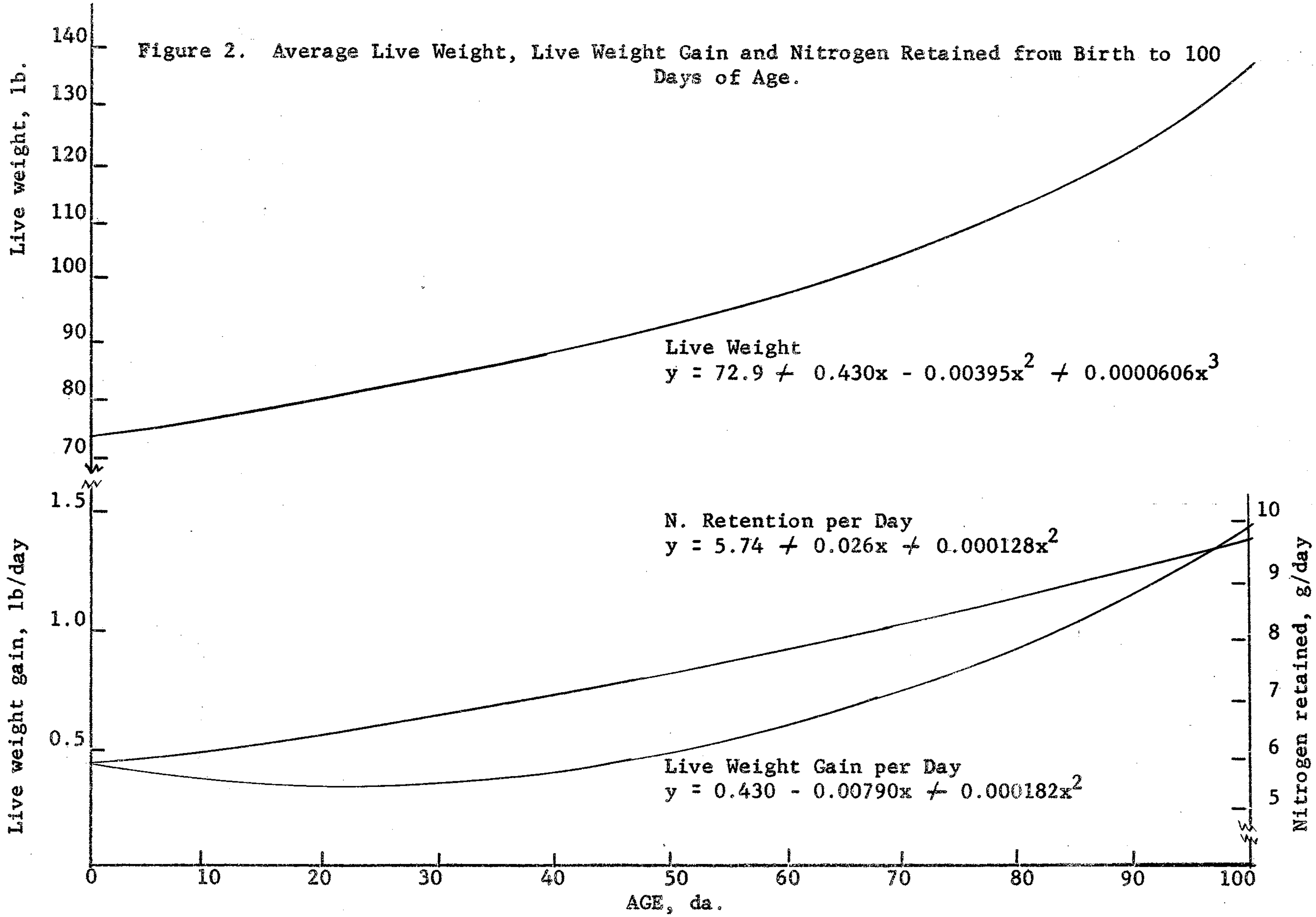


Figure 2. Average Live Weight, Live Weight Gain and Nitrogen Retained from Birth to 100 Days of Age.

TABLE 2

RELATIONSHIP BETWEEN DAILY NITROGEN RETENTION AND DAILY LIVE WEIGHT GAIN

Age	Lwt. gain/day	Nitrogen retained/day	Nitrogen retained per lb. gain in lwt.
da.	lb.	g.	g.
0	.43	5.74	13.3
10	.37	6.01	16.2
20	.34	6.31	18.6
30	.36	6.64	18.4
40	.41	7.04	17.2
50	.49	7.36	15.0
60	.61	7.76	12.7
70	.77	8.19	10.6
80	.96	8.64	9.0
90	1.19	9.12	7.7
100	1.46	9.62	6.6

On the average the rate of nitrogen retention appeared to vary in proportion to live weight to the 0.79 power when no consideration was given to age. One hundred per cent increase in live weight was associated with 79 per cent increase in the retention of nitrogen. While further work is needed to estimate a more absolute value for this exponent, it can be argued that it is of logical order.

Brody (57) has shown quite conclusively that the metabolic rate can be expressed in terms of live weight to the 0.73 power. A similar proportionality should be expected between the rate of growth or nitrogen retention and live weight since growth may be considered as a function of the metabolic rate. Furthermore, this concept of metabolism is based on the relationship between live weight (mass) and physiological surface. That portion of growth which involves cell division may be thought of as change in surface and thus be related to live weight to the 0.73 power. On the other hand, growth is also characterized by cell enlargement which might be considered more in terms of an increase in mass, and consequently such growth could be described more nearly in direct proportion to live weight.

The exponential increase of nitrogen retained (growth) per unit of live weight then, might be expected to fall between 0.73 and 1.0 since growth involves increases in both surface and mass. The absolute evaluation of such an exponent would be dependent upon the reliability of live weight as an expression of body weight. This is especially critical in the young calf which is losing tissue moisture and rapidly gaining body fill.

The retention of nitrogen per unit of mass may be related to age. The retention of protein (nitrogen x 6.25) per 100 pounds of live weight was plotted against age. The retention of protein was 0.123 pounds at birth and decreased to 0.080 pounds per 100 pounds of live weight at 60 days of age. After this age the retention of protein per unit of live weight appeared to level off, but after 100 days began to show a slight increase. Such an increase would not be expected and in this case probably represented a distortion due to the limited age span involved. Although more work involving longer periods of time is necessary, these values followed a similar trend to data summarized by Armsby (2). There was similarity in the decrease in rate of protein retained per unit of live weight with advancing age. Retention of protein per unit of live weight appeared to be appreciably lower in this study than in Armsby's if the curves were projected back to the intrauterine stage.

It may be more logical to study nitrogen retention by plotting nitrogen retained per unit of gain in live weight against age since retention of nitrogen may be considered an indirect reference of metabolic growth. Nitrogen retained per unit of gain in live weight was greater at 20 to 30 days of age than at any other time as shown in Table 2. The retention of nitrogen was 13.3 g. per pound of gain in live weight when the respective curves were projected back to zero days of age. This value increased to 18.6 g. at 20 days of age then gradually decreased to 6.6 g. per pound of live weight gain at 100 days of age. This apparent inconsistency with respect to the relationship between nitrogen retention and live weight gain was due undoubtedly to the inability to estimate true tissue growth.

The increase in nitrogen retained per pound of gain from birth to 20 days of age may be attributed, at least partially, to a decrease in body tissue moisture. A loss of tissue moisture would correspondingly raise the proportion of nitrogen per unit of daily gain in live weight.

The apparent decrease in nitrogen retained per pound of gain from 20 to 100 days of age was probably associated with the development of the rumen from a relatively small, quiescent organ to one of considerable size at 100 days of age. A relatively rapid gain of body fill during this period could result in marked over-estimates of the rates of growth by the use of live weight gain measurements. Nevertheless, a properly evaluated "working ratio" between nitrogen retention and live weight gain could be helpful in interpreting nitrogen utilization data.

The conventional method of estimating daily gain by difference between the average of three daily live weight measurements taken before and after a metabolism trial was not satisfactory. There was considerable variation of the last three daily weights, apparently caused by variation in body fill, although the conditions of the live weight measurements were carefully controlled. The live weights observed on the 2nd and 3rd days after removal from the metabolism stall were markedly higher than the live weights taken on the 1st day. The nature of the daily increase in these weights was such that it was obvious that live weight gain was being influenced markedly by other factors than the growth of body tissue. The calves were maintained on the same constant level of feed intake as during the collection period for three days after removal from the metabolism stalls, and water was accessible at all times. The peculiarity of the three daily weights may have been due to erratic increases in the consumption of water on the 2nd or 3rd day, in some cases later, after removal from the metabolism stall. Water consumption may have been decreased due to the confinement of the metabolism stalls with recovery influenced by the stimulus of more freedom of movement after removal of the calves to the holding stalls.

Since this difficulty was encountered, live weight curves were developed from which gains could be estimated. All live weights except those observed three days after each trial were plotted against days of age. An equation was fitted by the method of least squares to these data points for each calf, and live weight gains were estimated by differentiation of the equation at the appropriate points in time. The individual calf growth curves and the respective equations are shown in figs. 1 through 8 of the appendix. The slope of the growth curves during trial VI may have been less if live weight measurements had been available beyond this trial and used in the calculation of the equation. The live weight data of individual calves are listed in tabular form in Tables XI and XII of the appendix.

Estimation of the daily gain over a short period appeared to be more logical by the mathematical method. Table 3 shows a comparison between nitrogen retention values per pound of gain as determined by the mathematical method and as calculated by the conventional method of estimating daily live weight gain. In review of this table, several negative values of nitrogen retained per pound of gain are observed when the gain was estimated by the conventional method. Such negative values for nitrogen retained per pound of gain seemed obviously erroneous and not logically possible.

TABLE 3

COMPARISONS BETWEEN VALUES FOR LIVE WEIGHT, LIVE WEIGHT GAIN AND NITROGEN RETAINED BASED ON TWO METHODS OF ESTIMATING LIVE WEIGHT GAIN

Calf No.	Trial No.	Lwt. at Center Day of Collection		Lwt. gain per Day		Nitrogen Retained per 100 lb. Lwt.		Retained per lb. of gain	
		1	2	1	2	1	2	1	2
		lb.	lb.	g.	g.	lb.	lb.	g.	g.
H 21	1	104	103	0.72	0.57	7.40	7.48	10.69	13.5
	2	121	128	0.40	0.46	8.93	8.44	22.00	23.5
	3	---	---	----	----	----	----	-----	----
	4	161	171	1.00	1.39	4.30	4.05	6.93	5.0
	5	194	200	1.00	1.63	4.82	4.68	9.36	5.7
	6	215	230	1.17	1.86	6.16	5.76	11.32	7.1
H 59	1	107	116	0.22	0.72	9.91	9.14	48.18	14.7
	2	125	125	0.50	0.25	11.67	11.67	29.18	58.4
	3	128	130	-0.22	0.48	6.60	6.50	-38.41	17.6
	4	138	144	0.60	1.22	7.16	6.86	16.47	8.1
	5	180	197	1.23	3.22	10.78	9.86	15.79	6.0
	6	---	---	----	----	----	----	-----	----
G 112	1	79	82	0.43	0.28	----	----	-----	----
	2	88	86	0.11	0.34	7.45	7.27	59.64	19.3
	3	---	---	----	----	----	----	-----	----
	4	100	102	0.56	0.59	6.08	5.96	10.86	10.3
	5	120	122	0.62	0.91	7.71	6.32	12.44	8.5
	6	143	151	0.67	1.32	8.82	8.35	18.82	9.6
G 143	1	73	72	1.36	0.25	5.50	5.55	2.94	16.0
	2	79	78	0.33	0.33	5.47	5.54	13.10	13.1
	3	87	86	0.56	0.46	7.93	8.02	12.32	15.0
	4	97	100	0.88	0.67	10.64	10.32	11.73	15.4
	5	107	111	0.89	0.83	6.25	6.03	7.52	8.1
	6	122	134	-0.89	1.13	3.16	2.87	-4.33	3.4
A 43	1	75	75	0.78	0.48	15.17	15.17	14.58	23.7
	2	---	---	----	----	----	----	-----	----
	3	101	104	0.71	0.86	9.68	9.40	13.77	11.4
	4	115	118	0.18	0.98	4.67	4.55	29.83	5.5
	5	139	137	1.18	1.11	9.91	10.06	11.67	12.4
	6	162	167	0.91	1.28	10.41	10.10	18.44	13.2

(continued)

Table 3 (Continued)

Calf No.	Trial No.	Lwt. at Center Day of Collection 1	2	Lwt. gain per Day 1	2	Nitrogen Retained per 100 lb. Lwt. 1	2	Retained per lb. of gain 1	2
		lb.	lb.	g.	g.	lb.	lb.	g.	g.
A 43	1	75	75	0.78	0.48	15.17	15.17	14.58	23.7
	2	---	---	----	----	----	----	-----	----
	3	101	104	0.71	0.86	9.68	9.40	13.77	11.4
	4	115	118	0.18	0.98	4.67	4.55	29.83	5.5
	5	139	137	1.18	1.11	9.91	10.06	11.67	12.4
	6	162	167	0.91	1.28	10.41	10.10	18.44	13.2
J 63	1	60	64	0.00	0.12	6.15	5.76	-----	30.8
	2	---	---	----	----	----	----	-----	----
	3	74	72	1.71	0.50	17.70	18.19	7.66	26.2
	4	84	82	0.67	0.77	7.18	7.35	9.00	7.8
	5	109	108	0.25	1.28	7.47	7.47	32.56	6.4
	6	137	161	-0.10	1.99	7.64	6.50	-104.70	5.3
G 88	1	67	68	0.38	0.42	6.93	6.84	12.13	10.9
	2	76	76	-0.30	0.25	5.12	4.86	-12.96	15.5
	3	78	81	-0.33	0.27	1.26	1.17	- 2.97	3.6
	4	87	89	0.50	0.46	10.29	10.06	17.90	19.4
	5	---	118	----	0.95	----	3.56	-----	4.2
	6	117	124	-0.09	1.29	7.57	6.47	-98.44	6.8
A 49	1	52	52	0.22	0.14	9.75	9.75	23.04	36.2

1. Based on live weights computed from average of 3 day weights before and after collection.

2. Based on live weights computed from the individual growth formula.

The average rate of gain in live weight as determined by the mathematical method is shown graphically in fig. 2. The average of the daily gain in live weight of all calves was 0.43 pounds at birth. The daily gain declined to 0.34 pounds at 20 days of age after which it increased to 1.46 pounds by 100 days of age.

The apparent digestibility values of the nitrogen and total digestible nutrients of each trial for each calf are shown in Table X and the average for all calves for each trial is shown in Table 4. The pre-determined nitrogen intake was based upon Morrison's average coefficients of digestibility for the protein of the particular feed ingredients of the ration. Digestible nitrogen as determined in this study was equal to the calculated value in trial II, but was 19 per cent below the calculated value in trial VI.

The percent of total digestible nutrients decreased apparently as the fiber and bulk of the ration increased with advancing age. The total digestible nutrients as determined by trial was 2 per cent below the calculated value in trial II and was 8 per cent below in trial VI. Digestibility of the milk ration as determined by trial would be expected to be comparable to the calculated values since these were probably based on coefficients originally determined with young calves. However, the tabular digestion coefficients for the grain and hay ration were determined with adult animals and therefore would not be expected to be comparable to values determined with young calves.

Neither the milk and grain in trials III and IV nor the grain and hay in trials V and VI were offered in the same amounts with respect to each other for each calf, but were adjusted according to live weight of the calf before the trial. These different feed ratios may have

TABLE 4

AVERAGE DIGESTIBILITY OF RATIONS

Trial No.	Nitrogen %	Tot. Nutrients %	Ration
I	92	95	Whole milk
II	95	96	Whole milk
III	87	90	Whole milk and grain
IV	78	82	Whole milk and grain
V	65	71	Grain and Prairie hay
VI	60	68	Grain and Prairie hay

caused slight variations in the digestibilities as observed in the rations of each trial and of individual calves.

The digestibility of the milk ration of trial I was lower on the average than in trial II. This may have been influenced by the consumption of fiber from the bedding before trial I. The possibility of contaminating the ration with bedding was eliminated after this trial by placing the calves on rubber mats while they were in the holding stalls.

SUMMARY

Thirty eight nitrogen retention balance trials were conducted with eight young male dairy calves at various intervals from birth to 120 days of age.

The retention of nitrogen was in the proportion to live weight to the 0.79 power. Nitrogen retained daily per unit of live weight gain was higher from birth to 20 days of age than it was from 20 to 100 days of age.

The apparent digestibility of nitrogen and total nutrients was lower than the respective calculated average coefficient of digestibility for each ration, except the milk ration. The apparent digestibility decreased with increasing bulk of the ration.

The least squares method was used in determining growth curves and daily gains in live weight for individual calves. Daily gain in live weight was variable among individual calves at all ages throughout this study.

LITERATURE CITED

(1) AGRAWALA, I. P., DUNCAN, C. W., AND HUFFMAN, C. F. A Quantitative Study of Rumen Synthesis in the Bovine on Natural and Purified Rations; I. Protein, Dry Matter and Non-Protein Nitrogen. J. Nutrition, 49: 29-39. 1952.

(2) ARMSBY, H. P. The Nutrition of Farm Animals. Macmillan Publishing Co. New York, N. Y. 1917.

(3) ARMSBY, H. P. Cooperative Experiments Upon the Protein Requirements for the Growth of Cattle. Bulletin of the National Research Council, 12. 1921.

(4) ARMSBY, H. P. AND MOULTON, C. R. The Animal as a Convertor of Matter and Energy. American Chemical Society Monograph Series No. 23. The Chemical Catalog Co., Inc., 19 East 24th St., New York, N. Y. 1925.

(5) ASHWORTH, U. S. Growth and Development: With Special Reference to Domestic Animals; Endogenous Nitrogen and Basal Energy Relationships During Growth. Mo. Agr. Expt. Res. Bull., 223: 1-20. 1934.

(6) BLAXTER, K. L. AND MITCHELL, H. H. The Factorization of the Protein Requirements of Ruments and of the Protein Values of Feeds; With Particular Reference to the Significance of the Metabolic Fecal Nitrogen. J. Animal Sci., 7: 351-72. 1948.

(7) BLAXTER, K. L. AND PRICE, H. A. Experiments on the Use of Home-Grown Foods for Milk Production: Protein Requirements of Growing Dairy Heifers. J. Agr. Sci., 36: 301-9. 1946.

(8) BLAXTER, K. L. AND WOOD, W. A. The Nutrition of the Young Ayrshire Calf; I. The Endogenous Nitrogen and Basal Energy Metabolism of the Calf. Brit. J. Nutrition, 5: 11-67. 1951.

(9) BOSSHARDT, D. K., PAUL, W., O'DOHERTY, K. AND BARNES, R. H. The Influence of Caloric Intake on the Growth Utilization of Dietary Protein. J. Nutrition, 32: 641. 1946.

(10) BOSSHARDT, D. K., AND BARNES, R. H. The Determination of Metabolic Fecal Nitrogen and Protein Digestibility. J. Nutrition, 31: 13-21. 1946.

(11) BRODY, SAMUEL AND ASSISTANTS. Growth and Development: Energy and Nitrogen Metabolism During the First Year of Postnatal Life. Mo. Expt. Res. Bull., 143: 183-208. 1930.

(12) BUSH, L. F., WILLMAN, J. P. AND MORRISON, F. B. Study of the Protein Requirements of Fattening Feeder Lambs. J. Animal Sci., 14: 465-9. 1955.

(13) CALLOWAY, D. H. AND SPECTOR, H. Nitrogen Utilization During Caloric Restriction: Effect of Dietary Fat Content. J. Nutrition, 56: 533-44. 1955.

(14) CALLOWAY, D. H. AND SPECTOR, H. Nitrogen Utilization During Caloric Restriction: Effect of Variation in Nitrogen Intake. J. Nutrition, 56: 545-54. 1955.

(15) CALLOWAY, D. H. AND SPECTOR, H. Nitrogen Utilization During Caloric Restriction: Effect of Preceding Diet. J. Nutrition, 57: 73-88. 1955.

(16) CONRAD, H. R. AND HIBBS, J. W. A High Roughage System for Raising Dairy Calves Based on the Early Development of Rumen Function III; Effect of Rumen Inoculations and the Ratio of Hay to Grain on Digestion and Nitrogen Retention. J. Dairy Sci., 36: 1326-34. 1953.

(17) DUNCAN, C. W., AGRAWALA, I. P., HUFFMAN, C. F. AND LUECKE, R. W. A Quantitative Study of Rumen Synthesis in the Bovine on Natural and Purified Rations. II; Amino Acid Content of Mixed Rumen Proteins. J. Nutrition, 49: 41-49. 1952.

(18) FONTENOT, F. P. Effects of Added Carbohydrate on the Utilization by Steers of Nitrogen in Wintering Rations. J. Animal Sci., 14: 807-817. 1955.

(19) FORBES, E. B., BECHDEL, C. I., JEFFRIES, C. D. AND KRISS, MAX. Cooperative Experiments upon the Protein Requirements for the Growth of Cattle. II; Bulletin of the National Research Council, 42. 1924.

(20) HARRIS, L. J. AND LOOSLI, J. K. The Minimum Protein Requirements of Young Holstein Calves. J. Dairy Sci., 27: 650-51. 1944. (Abs.)

(21) HUMBLE, E. W. Protein Requirements of Dairy Calves. Thesis. Partial Fulfillment of the Requirement for the Degree of Master of Science. Oklahoma A & M College. 1955.

(22) KLEINER, I. S. Human Biochemistry. 4th Edition. The C. V. Mosby Company. St. Louis, Mo. 1945.

(23) LOFGREEN, G. P. AND KLEIBER, M. Metabolic Fecal Nitrogen Excretion of the Young Calf and the True Digestibility of Casein. J. Nutrition, 49: 183-30. 1953.

(24) LOFGREEN, G. P., LOOSLI, J. K. AND MAYNARD, L. A. Influence of Protein Source Upon Nitrogen Retention by Sheep. J. Animal Sci., 6: 343-7. 1947.

(25) LOFGREEN, G. P., LOOSLI, J. K. AND MAYNARD, L. A. The Influence of Energy Intake on the Nitrogen Retention of Growing Calves. J. Dairy Sci., 34: 911-15. 1951.

(26) LOFGREEN, G. P., LOOSLI, J. K. AND MAYNARD, L. A. Comparative Study of Conventional Protein Allowances and Theoretical Requirements of Growing Holstein Heifers. J. Animal Sci., 10: 171-83. 1951.

(27) LOOSLI, J. K., HUFFMAN, C. F., PETERSEN, W. E. AND PHILLIPS, P. H. Recommended Nutrient Allowances for Domestic Animals III: Recommended Nutrient Allowances for Dairy Cattle. Natl. Res. Council, 2101 Constitution Ave., N. W. Washington 25, D. C. 1953.

(28) LOOSLI, J. K., WILLIAMS, H. H., THOMAS, W. E. AND MAYNARD, L. A. Synthesis of Amino Acids in the Rumen. Sci., 110: 144. 1949.

(29) LOVELL, M. E. AND RABINOWITCH, I. M. Factors Influencing Storage of Protein with Low Caloric Diets. J. Nutrition, 18: 339-51. 1939.

(30) MCDONALD, I. W. The Role of Ammonia in Ruminal Digestion of Protein. Biochem. J., 51: 86-90. 1952.

(31) MCNAUGHT, M. L. AND SMITH, J. A. B. Nitrogen Metabolism in the Rumen. Nutr. Abs. and Rev., 17: 18. 1947.

(32) MUKHERJEE, R. AND MITCHELL, H. H. Basal Energy and Nitrogen Metabolism of Dairy Calves in Hyperthyroidism Induced by Thyroprotein Administration. J. Animal Sci., 10: 149-62. 1951.

(33) MILLS, R. C., LARDINOIS, C. C., RUPEL, I. W. AND HART, E. B. Utilization of Urea and Growth of Heifer Calves with Corn Molasses or Cane Molasses as the Only Readily Available Carbohydrates in the Ration. J. Dairy Sci., 27: 571-8. 1944.

(34) MITCHELL, H. H. Minimum Protein Requirements of Cattle. Bull. of Natl. Res. Council., 67. 1929.

(35) MITCHELL, H. H. AND BERT, M. H. Determination of Metabolic Fecal Nitrogen. J. Nutrition, 52: 483-97. 1954.

(36) MITCHELL, H. H., HAMILTON, R. S. AND HAINES, W. T. Utilization by Calves of Energy in Rations Containing Different Percentages of Protein and in Glucose Supplements. J. Agr. Res., 61: 847-64. 1940.

(37) MORRISON, F. B. Feeds and Feeding. 20th Edition. Morrison Publishing Co. Ithaca, N. Y. 1936.

(38) MORRISON, F. B. Feeds and Feeding. 21st Edition. Morrison Publishing Co. Ithaca, N. Y. 1948.

(39) MUNRO, H. N. Carbohydrate and Fat as Factors in Protein Utilization and Metabolism. Physiological Review, 31: 449. 1951. (A Review)

(40) MUNRO, H. N. AND WIKRAMANAYDE, T. W. Absence of a Time Factor in the Relationship Between Level of Energy Intake and Protein Metabolism. J. Nutrition, 52: 99-114. 1954.

(41) NEVENS, W. B., HENDRICHSON, J. W. AND DAVIS, H. P. Growth Studies of Dairy Heifers II; Protein Requirements for Growing Heifers. Nebr. Agr. Expt. Sta. Bull., 184. 1923.

(42) NORTON, C. L. AND EATON, H. D. Dry Calf Starters for Dairy Calves. Cornell Agr. Expt. Sta. Bull., 835. 1946.

(43) PERKINS, A. E. AND MONROE, C. F. Effect of High and Low Protein Content on the Digestibility and Metabolism of Dairy Rations. Ohio Agr. Expt. Sta. Bull., 376. 1924.

(44) RITZMAN, E. G. AND COLOVOS, N. F. Physiological Requirements and Utilization of Protein and Energy by Growing Dairy Cattle. N. H. Agr. Expt. Sta. Tech. Bull., 80. 1943.

(45) ROBINSON, J. F. Protein Supplements for Growing Calves; Observation Trials at Bangor. J. Ministry Agr., 54: 54-9. 1947.

(46) ROSENTHAL, H. L. AND ALLISON, J. B. Some Effects of Caloric Intake on Nitrogen Balance in Dogs. J. Nutrition., 44: 423-31. 1931.

(47) SCHNEIDER, B. H. The Relationship of the Metabolic Nitrogen of the Feces to Body Weight and to Food Intake for Rats. Biochem. J., 28: 360-64. 1934.

(48) SCHREIBER, M. AND ELVEHJEM, C. A. Water Restriction in Nutrition Studies: Level of Fat and Protein Utilization. J. Nutrition, 57: 133-45. 1955.

(49) SMUTS, D. B. AND MARAIC, J. S. C. Endogenous Nitrogen Metabolism of Sheep With Special Reference to the Maintenance Requirement of Protein. Onderstepoort J. Vet. Sci., 11: 131-9. 1939.

(50) SWETT, W. W., ECKLES, C. H. AND RAGSDALE, A. C. The Minimum Protein Requirements for Growing Dairy Heifers. Mo. Agr. Expt. Sta. Res. Bull., 66. 1924.

(51) THOMSON, W. S. T. AND MUNRO, H. N. The Relationship of Carbohydrate Metabolism to Protein Metabolism: The Effect of Substituting Fat for Dietary Carbohydrate. J. Nutrition, 65: 139-50. 1955.

(52) TILLMAN, A. D. AND MACVICAR, R. Effect of Chlortetracycline upon Digestion of Ration Components, Retention of Nitrogen and Volume of Urine Excreted by Sheep with Observations on Rectal Temperature. J. Animal Sci., 15: 211-17. 1956.

(53) TRIMBERGER, G. W. AND DAVIS, H. P. Protein Supplements in Dry Calf Starters for Calves on Limited Quantities of Milk. Nebr. Agr. Expt. Bull., 134. 1944.

(54) WEGNER, M. E., BOOTH, A. N., BOHSTEDT, G. AND HART, E. B. The Utilization of Urea by Ruminants as Influenced by the Level of Protein in the Ration. J. Dairy Sci., 24: 835-44. 1951.

(55) WISE, G. H., PETERSEN, W. E., AND GULLICKSON, T. W. Comparative Physiological Responses of Dairy Calves Fed Rations Having Different Levels of Milk Proteins. J. Dairy Sci., 23: 91-102. 1940.

(56) ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. Official Methods of Analyses. 8th Edition. Published by A.O.A.C. Washington 4, D. C. 1955.

(57) BRODY, SAMUEL. Bioenergetics and Growth. Reinhold Publishing Corporation. New York, N. Y. 1945.

(58) MICKLE, J. B., MUSGRAVE, S. D., WALTER, R. E., GRAYBILL, F. A., LOEWENSTEIN, M. AND JOHNSON, P. E. Okla. Agr. Expt. Sta. T. Bull. T-67. 1957.

A P P E N D I X

APPENDIX

Appendix (Continued)

TABLES PAGE

TABLE I

HOLSTEIN NO. 21

Tr. No.	Material	Daily amt.	D M	Prot.	E E	Fiber	NFE	Ash	N[1]
		Composition of Feed, Feces and Urine							
		g.	%	%	%	%	%	%	%
1.	Milk	4089	10.3	2.86	2.76	--	4.02	0.66	0.448
	Feces	150	14.13	9.44	1.05	0.12	1.83	1.69	1.51
	Urine	6789	--	--	--	--	--	--	0.123
2.	Milk	4906	11.3	3.07	2.95	--	4.64	0.64	0.482
	Feces	81	26.50	13.38	1.52	3.34	1.88	6.37	2.14
	Urine	8000	--	--	--	--	--	--	0.139
3.	(None)								
4.	Milk	456	11.8	3.45	3.45	--	4.26	0.64	0.540
	Grain Fed	1228	91.96	16.96	3.25	5.89	58.78	7.09	2.71
	Feces	1110.4	26.87	6.06	0.37	5.65	11.83	2.96	0.97
	Urine	4000	--	--	--	--	--	--	0.451
5.	Grain Fed	1362	91.38	17.08	3.09	6.13	58.00	7.08	2.73
	Hay Fed	908	90.80	4.89	2.31	32.41	45.51	5.69	0.78
	Hay Ref.	64	90.25	4.23	1.76	37.85	40.74	5.67	0.68
	Feces	2923	23.80	4.54	0.43	5.74	10.74	2.35	0.73
	Urine	4000	--	--	--	--	--	--	0.328
6.	Grain Fed	1544	91.91	17.46	3.06	5.57	59.10	6.72	2.79
	Hay Fed	1180	91.66	4.70	2.28	29.18	48.98	6.51	0.75
	Feces	3813	24.67	4.26	0.63	5.80	11.42	2.56	0.68
	Urine	4000	--	--	--	--	--	--	0.319

[1]Nitrogen in milk and urine recorded as g./100 ml.

TABLE II

HOLSTEIN NO. 59

Tr. No.	Material	Daily amt.	Composition of Feed, Feces and Urine: D M	Prot.	E E	Fiber	NFE	Ash	N[1]
		g.	%	%	%	%	%	%	%
1.	Milk	4085	11.7	3.11	3.40	--	4.65	0.64	0.487
	Feces	67	18.32	11.00	1.37	0.16	4.22	1.55	1.76
	Urine	4200	--	--	--	--	--	--	0.193
2.	Milk	4994	11.8	3.44	3.30	--	4.42	0.64	0.539
	Feces	60.4	23.77	8.81	4.22	3.92	3.67	3.15	1.41
	Urine	4000	--	--	--	--	--	--	0.287
3.	Milk	627	11.5	3.26	2.90	--	4.70	0.64	0.511
	Grain Fed	1008	93.00	17.44	3.46	6.47	58.08	7.45	2.79
	Grain Ref.	61.6	88.46	16.92	3.00	5.75	56.25	6.54	2.71
	Feces	317	27.00	7.50	0.54	5.17	10.12	3.67	1.20
	Urine	4000	--	--	--	--	--	--	0.435
4.	Milk	543	11.6	3.16	3.40	--	4.40	0.64	0.495
	Grain Fed	1180	91.71	17.09	3.07	6.15	59.25	6.14	2.73
	Grain Ref.	70	90.30	16.99	3.06	5.92	58.38	5.95	2.72
	Feces	765	27.60	6.43	0.58	5.32	12.11	3.17	1.03
	Urine	4000	--	--	--	--	--	--	0.381
5.	Grain Fed	1408	90.76	18.55	4.22	5.37	57.79	4.83	2.97
	Hay Fed	544	89.62	4.76	1.88	30.18	46.95	5.84	0.76
	Hay Ref.	133	87.22	4.85	2.49	27.82	45.46	6.60	0.78
	Feces	1740	28.27	4.88	0.46	7.21	12.91	2.81	0.78
	Urine	4000	--	--	--	--	--	--	0.298
6.	(None)								

[1]Nitrogen in milk and urine recorded as g./100 ml.

TABLE III

GUERNSEY NO. 88

Tr. No.	Material	Daily amt.	Composition of Feed, Feces and Urine						
			D M	Prot.	E.E	Fiber	NFE	Ash	N[1]
		g.	%	%	%	%	%	%	%
1.	Milk	2818	10.8	2.76	3.05	--	4.35	0.64	0.433
	Feces	37.8	27.46	17.01	5.91	0.59	1.58	2.37	2.72
	Urine	4000	--	--	--	--	--	--	0.164
2.	Milk	3111	11.0	2.77	2.95	--	4.65	0.63	0.434
	Feces	39.6	25.53	9.49	4.04	4.79	4.57	2.64	1.52
	Urine	4173	--	--	--	--	--	--	0.216
3.	Milk	1455	10.9[illegible]	3.15	3.30	--	3.81	0.64	0.494
	Grain Fed	498	91.52	17.51	3.20	6.12	57.50	7.18	2.80
	Grain Ref.	357	91.39	16.73	3.52	5.71	58.57	6.85	2.68
	Feces	110	25.73	7.38	0.79	4.31	8.98	4.27	1.18
	Urine	4000	--	--	--	--	--	--	0.232
4.	Milk	1338	12.0	3.34	3.55	--	4.47	0.64	0.523
	Grain Fed	498	91.62	17.76	3.20	5.87	57.78	7.01	2.84
	Feces	422.6	25.70	6.38	0.41	4.56	11.71	2.64	1.02
	Urine	4000	--	--	--	--	--	--	0.192
5.	Grain Fed	908	92.05	17.20	3.61	6.36	59.10	5.78	2.75
	Hay Fed	272.4	91.89	4.94	2.44	31.68	47.27	5.55	0.79
	Hay Ref.	45.4	88.77	5.33	2.26	31.82	43.76	5.59	0.85
	Feces	1064	28.23	5.38	0.75	6.75	12.40	2.95	0.86
	Urine	4000	--	--	--	--	--	--	0.340
6.	Grain Fed	1090	91.57	17.34	3.42	5.99	58.48	6.35	2.77
	Hay Fed	363	86.05	4.78	2.14	32.59	41.67	4.87	0.77
	Hay Ref.	19	86.34	4.91	2.22	32.20	42.16	4.85	0.79
	Feces	1555	27.03	5.25	0.52	6.14	12.41	2.70	0.84
	Urine	4000	--	--	--	--	--	--	0.273

[1]Nitrogen in milk and urine recorded as g./100 ml.

TABLE IV

GUERNSEY NO. 143

Tr. No.	Material	Daily amt.	Composition of Feed, Feces and Urine						
			D M	Prot.	E E	Fiber	NFE	Ash	N[1]
		g.	%	%	%	%	%	%	%
1.	Milk	2800	11.5	3.08	3.20	--	4.57	0.65	0.483
	Feces	39.6	22.22	13.93	3.78	0.16	2.73	1.61	2.23
	Urine	4000	--	--	--	--	--	--	0.216
2.	Milk	3198	11.3	3.03	3.20	--	4.43	0.64	0.475
	Feces	71.2	26.83	10.82	3.50	4.40	2.52	5.59	1.73
	Urine	4000	--	--	--	--	--	--	0.241
3.	Milk	1637	12.1	3.32	3.40	--	4.74	0.64	0.521
	Grain Fed	498	91.53	17.05	3.06	5.82	58.71	6.89	2.73
	Grain Ref.	37	89.24	16.73	3.15	5.82	57.01	6.53	2.68
	Feces	351.8	26.53	7.25	0.72	4.74	10.56	3.28	1.16
	Urine	4000	--	--	--	--	--	--	0.254
4.	Milk	1382	11.5	3.42	3.40	--	4.04	0.64	0.536
	Grain Fed	682	92.46	17.69	3.00	6.62	57.71	7.44	2.83
	Feces	508	27.17	5.91	0.36	5.67	12.58	2.65	0.95
	Urine	4000	--	--	--	--	--	--	0.289
5.	Grain Fed	908	92.52	17.58	3.22	6.05	59.93	5.74	2.81
	Hay Fed	181.6	90.62	5.04	2.38	31.63	45.81	5.76	0.81
	Hay Ref.	9.1	89.62	4.98	2.23	34.31	43.14	4.96	0.80
	Feces	1118	27.27	5.32	0.59	6.43	12.35	2.59	0.85
	Urine	4000	--	--	--	--	--	--	0.268
6.	Grain Fed	1090	91.28	17.52	3.53	5.92	57.91	6.40	2.80
	Hay Fed	364	88.53	4.76	2.39	31.05	44.41	5.92	0.76
	Feces	1497	29.23	5.55	0.65	6.32	13.70	3.01	0.89
	Urine	4000	--	--	--	--	--	--	0.403

[1]Nitrogen in milk and urine recorded as g./100 ml.

TABLE V

GUERNSEY NO. 112

Tr. No.	Material	Daily amt.	Composition of Feed, Feces and Urine						
			D M	Prot.	E E	Fiber	NFE	Ash	N[1]
		g.	%	%	%	%	%	%	%
1.	Milk	3270	11.4	3.10	3.40	--	4.26	0.64	0.486
	Feces	181	25.27	7.94	15.71	0.26	--	2.94	1.27
	Urine	4000	--	--	--	--	--	--	0.347
2.	Milk	3272	11.8	3.42	3.45	--	4.29	0.64	0.536
	Feces	1148	31.47	9.70	6.26	4.11	6.15	5.25	1.55
	Urine	4000	--	--	--	--	--	--	0.256
3.	(None)								
4.	Milk	1179	10.9	3.11	3.30	--	3.85	0.64	0.487
	Grain Fed	636	91.95	17.07	3.48	6.10	58.15	7.16	2.73
	Feces	519	27.23	6.59	0.74	5.25	11.62	3.03	1.06
	Urine	4000	--	--	--	--	--	--	0.288
5.	Grain Fed	1044	91.68	18.68	4.18	4.94	58.89	4.99	2.99
	Hay Fed	272	89.08	4.73	2.11	29.31	46.83	6.10	0.76
	Feces	1133	30.40	6.64	0.64	6.88	12.73	3.64	1.04
	Urine	4000	--	--	--	--	--	--	0.345
6.	Grain Fed	1226	91.55	19.12	4.15	5.49	57.55	5.25	3.06
	Hay Fed	500	91.46	4.23	2.19	32.53	46.76	5.74	0.68
	Feces	1787	26.17	5.30	0.53	5.82	11.77	2.75	0.85
	Urine	4000	--	--	--	--	--	--	0.328

[1]Nitrogen in milk and urine recorded as g./100 ml.

TABLE VI

JERSEY No. 63

Tr. No.	Material	Daily amt.	Composition of Feed, Feces and Urine						
			D M	Prot.	E E	Fiber	NFE	Ash	N[1]
		g.	%	%	%	%	%	%	%
1.	Milk	2454	11.4	3.22	2.50	--	5.04	0.64	0.504
	Feces	48	21.65	8.81	2.08	4.69	3.15	2.92	1.41
	Urine	4000	--	--	--	--	--	--	0.200
2.	(None)								
3.	Milk	1726	11.4	2.92	3.20	--	4.64	0.64	0.458
	Grain Fed	636	91.91	17.69	3.45	6.02	57.92	6.83	2.83
	Feces	215	27.17	8.63	1.01	3.54	10.71	3.28	1.38
	Urine	4000	--	--	--	--	--	--	0.246
4.	Milk	1544	12.4	2.97	3.80	--	4.99	0.64	0.466
	Grain Fed	454	90.83	18.51	3.60	4.90	59.07	4.76	2.96
	Feces	179	31.77	9.13	1.14	5.61	11.91	3.98	1.46
	Urine	4000	--	--	--	--	--	--	0.300
5.	Grain Fed	1000	91.08	18.67	3.92	5.52	58.14	4.84	2.99
	Hay Fed	228	91.58	4.18	2.23	31.96	47.55	5.66	0.67
	Feces	1157	26.93	5.12	0.53	6.20	12.30	2.78	0.82
	Urine	4000	--	--	--	--	--	--	0.345
6.	Grain Fed	1180	91.79	19.05	3.86	4.50	58.60	5.78	3.05
	Hay Fed	408	91.32	3.71	2.47	30.08	48.97	6.10	0.59
	Feces	1920	24.03	5.26	0.68	5.02	10.47	2.60	0.84
	Urine	4000	--	--	--	--	--	--	0.295

[1]Nitrogen in milk and urine recorded as g./100 ml.

TABLE VII

AYRSHIRE NO. 43

Tr. No.	Material	Daily amt.	Composition of Feed, Feces and Urine: D M	Prot.	E E	Fiber	NFE	Ash	N[1]
		g.	%	%	%	%	%	%	%
1.	Milk	2942	11.8	3.33	3.25	--	4.58	0.64	0.522
	Feces	11	21.78	12.25	1.75	1.05	4.63	2.10	1.96
	Urine	4000	--	--	--	--	--	--	0.094
2.	(None)								
3.	Milk	1179	11.2	3.02	3.20	--	4.34	0.64	0.474
	Grain Fed	636	91.57	17.45	3.29	5.98	57.86	6.99	2.79
	Grain Ref.	88	89.87	17.08	3.27	5.90	56.82	6.79	2.73
	Feces	357	19.68	7.12	0.45	3.71	5.82	2.58	1.14
	Urine	4000	--	--	--	--	--	--	0.177
4.	Milk	908	11.4	2.98	3.20	--	4.58	0.64	0.467
	Grain Fed	864	91.52	17.67	3.41	5.80	57.96	6.67	2.83
	Grain Ref.	77	87.99	17.33	3.15	5.47	55.62	6.42	2.77
	Feces	770	24.83	6.13	0.58	4.26	11.04	2.82	0.98
	Urine	4000	--	--	--	--	--	--	0.341
5.	Grain Fed	1180	92.01	18.98	4.08	5.35	58.73	4.88	3.04
	Hay Fed	454	89.66	4.76	2.06	30.44	46.53	5.86	0.76
	Hay Ref.	35	85.58	5.25	2.85	27.90	42.77	6.81	0.84
	Feces	1685	25.53	4.76	0.67	5.38	12.06	2.66	0.76
	Urine	4000	--	--	--	--	--	--	3.04
6.	Grain Fed	1408	91.78	19.27	4.07	5.06	58.36	5.02	3.08
	Hay Fed	556	91.84	4.25	2.09	31.72	48.04	5.73	0.68
	Feces	2021	25.57	4.87	0.47	5.61	12.08	2.53	0.78
	Urine	4000	--	--	--	--	--	--	0.363

[1]Nitrogen in milk and urine recorded as g./100 ml.

TABLE VIII

AYRSHIRE NO. 49

Tr. No.	Material	Daily amt.	D M	Prot.	E E	Fiber	NFE	Ash	N[1]
		Composition of Feed, Feces and Urine							
		g.	%	%	%	%	%	%	%
1.	Milk	2490	11.1	3.18	3.30	--	3.98	0.64	0.497
	Feces	45.7	24.50	13.12	2.77	0.72	4.27	3.62	2.10
	Urine	4000	--	--	--	--	--	--	0.160

[1]Nitrogen in milk and urine recorded as g./100 ml.

TABLE IX

NITROGEN CONSUMED, APPARENTLY DIGESTED AND RETAINED PER DAY

Calf No.	Trial No.	Age	Lwt.	Morrison's[1] Min. Rec. for Dig. Nitrogen/day	Total Nitrogen Consumed/Day	Nitrogen Apparently Digested/Day	Nitrogen Retained
		da.	lb.	g.	g.	g.	g.
H 21	1	12	104	22.66	18.32	16.05	7.70
	2	42	121	26.37	23.65	21.92	10.80
	3	--	---	-----	-----	-----	-----
	4	83	161	33.52	35.74	24.97	6.93
	5	102	194	40.39	44.26	22.92	9.36
	6	119	215	41.38	51.93	26.00	13.24
H 59	1	17	107	23.32	19.89	18.71	10.60
	2	38	125	27.24	26.92	26.07	14.59
	3	56	128	27.89	31.32	27.52	8.45
	4	73	138	30.07	34.90	27.02	9.88
	5	98	180	34.65	45.95	32.38	19.42
	6	--	---	-----	-----	-----	-----
G 88	1	11	67	16.22	12.20	11.17	4.61
	2	34	76	18.40	13.50	12.90	3.89
	3	58	78	18.88	11.56	10.26	0.98
	4	79	87	21.06	21.14	16.63	8.95
	5	107	---	-----	27.12	17.97	3.99
	6	121	117	25.49	32.99	19.93	8.86
G 143	1	12	73	17.67	13.52	12.64	4.00
	2	34	79	19.13	15.19	13.96	4.32
	3	55	87	21.06	22.13	18.05	6.90
	4	79	97	23.48	26.71	21.88	10.32
	5	94	107	23.32	26.98	17.48	6.69
	6	118	122	26.58	33.29	19.97	3.85
G 112	1	21	79	19.13	15.89	13.59	-0.29
	2	40	88	21.30	17.54	16.80	6.56
	3	---	---	-----	-----	-----	-----
	4	73	100	21.79	23.10	17.60	6.08
	5	100	120	26.15	33.29	21.51	7.71
	6	126	143	31.16	40.92	25.73	12.61

(Continued)

Table IX (Continued)

Calf No.	Trial No.	Age	Lwt.	Morrison's[1] Min. Rec. for Dig. Nitrogen/Day	Total Nitrogen Consumed/Day	Nitrogen Apparently Digested/Day	Nitrogen Retained
		da.	lb.	g.	g.	g.	g.
J 63	1	29	60	14.79	12.37	11.69	3.69
	2	---	---	-----	-----	-----	-----
	3	56	74	17.91	25.91	22.94	13.10
	4	72	84	20.34	20.64	18.03	6.03
	5	98	109	23.75	31.43	21.94	8.14
	6	129	137	29.85	38.40	22.27	10.47
A 43	1	20	75	18.16	15.36	15.14	11.38
	2	---	---	-----	-----	-----	-----
	3	63	101	22.01	23.33	19.26	9.78
	4	79	115	25.06	28.69	21.14	5.37
	5	97	139	30.29	39.32	26.57	13.78
	6	122	162	33.73	47.15	31.39	16.87
A 49	1	21	52	12.59	12.43	11.47	5.07

[1]Morrison's recommended D.P. allowance converted to equivalent amounts of nitrogen.

TABLE X

APPARENT DIGESTIBILITY OF NITROGEN AND APPARENT TOTAL DIGESTIBLE NUTRIENTS OF RATIONS

Trial No.	Calf	Nitrogen Consumed per Day	Apparent Digestibility of Nitrogen	Nutrients Consumed per Day	Apparent T.D.N.
		g.	%	g.	%
I	H 21	18.32	88	130.44	83
	H 59	19.89	94	130.31	98
	G 88	12.20	92	82.35	97
	G 143	13.52	93	86.80	98
	G 112	15.89	86	-----	--
	J 63	12.37	95	46.44	95
	A 43	15.36	99	93.34	99
	A 49	12.43	92	108.31	97
II	H 21	23.65	93	147.06	97
	H 59	26.92	97	159.06	98
	G 88	13.50	96	91.38	97
	G 143	15.19	92	56.41	92
	G 112	17.54	96	-----	--
	J 63	-----	--	-----	--
	A 43	-----	--	-----	--
	A 49	-----	--	-----	--
III	H 21	-----	--	-----	--
	H 59	31.32	88	203.61	91
	G 88	11.56	94	70.43	92
	G 143	22.13	82	137.00	86
	G 112	-----	--	-----	--
	J 63	25.91	89	175.56	93
	A 43	23.38	83	141.01	90
	A 49	-----	--	-----	--
IV	H 21	35.74	70	250.55	76
	H 59	34.90	77	229.51	81
	G 88	21.14	79	139.24	83
	G 143	26.71	82	174.76	84
	G 112	23.10	76	157.95	82
	J 63	20.64	87	139.46	91
	A 43	28.69	74	179.28	78
	A 49	-----	--	-----	--

(Continued)

Table X (Continued)

Trial No.	Calf	Nitrogen Consumed per Day	Apparent Digestibility of Nitrogen	Nutrients Consumed per Day	Apparent T.D.N.
		g.	%	g.	%
V	H 21	44.26	52	298.39	66
	H 59	45.95	70	247.47	71
	G 88	27.12	66	156.26	72
	G 143	26.98	65	207.72	70
	G 112	33.29	65	180.16	72
	J 63	31.43	70	167.86	73
	A 43	39.32	67	216.06	71
	A 49	-----	--	-----	--
VI	H 21	51.93	50	370.46	63
	H 59	-----	--	-----	--
	G 88	32.99	60	192.85	68
	G 143	33.29	60	196.88	67
	G 112	40.92	63	236.72	71
	J 63	38.40	58	217.89	69
	A 43	47.15	67	269.86	72
	A 49	-----	--	-----	--

TABLE XI

LIVE WEIGHT MEASUREMENTS

H-21		H-59		G-88		G-143	
Age da.	Lwt. lb.	Age da.	Lwt. lb.	Age da.	Lwt. lb.	Age da.	Lwt. lb.
0	95	0	100	0	55	0	70
2	97	2	104	2	69	2	73
6	101	11	106	5	64	5	71
7	101	12	106	6	66	6	69
8	101	19	105[a]	7	66	7	64
14	106[a]	20	107[a]	13	69[a]	14	77[a]
16	105[a]	21	113[a]	15	69[a]	16	78[a]
17	106	31	122	16	66	27	78
20	104	32	121	23	76	28	75
33	122	40	122[a]	26	75	29	76
35	117	41	130[a]	27	75	36	76[a]
36	117	42	130[a]	28	80	37	78[a]
44	119[a]	44	132	36	69[a]	38	85[a]
45	123[a]	48	128	37	76[a]	47	84
46	125[a]	49	128	38	76[a]	48	84
48	130	51	130	44	81	49	85
62	151	58	128[a]	52	80	50	83
69	154	59	126[a]	53	78	57	88[a]
70	159	60	128[a]	60	75[a]	58	90[a]
71	159	66	138	61	74[a]	59	90[a]
73	153	67	130	62	80[a]	62	91
74	157	75	140[a]	72	83	69	99
76	155	76	142[a]	73	84	71	90
77	157	80	157	81	87[a]	72	93
85	161[a]	87	166	82	90[a]	73	95
86	168[a]	88	166	83	91[a]	81	98[a]
87	169[a]	89	173	85	90	82	102[a]
89	178	90	178	92	98	89	103
92	182	101	186[a]	99	105	96	110[a]
93	189	102	186[a]	100	100	97	108[a]
94	190	103	192[a]	101	98	98	116[a]
105	198[a]	-	-	114	120	102	123
111	208	-	-	115	114	110	126
112	208	-	-	124	116[a]	111	124
122	219[a]	-	-	125	116[a]	112	128
123	222[a]	-	-	128	128	121	118[a]
124	224[a]	-	-	135	147	125	141
125	228	-	-	142	159	132	160
132	222	-	-	-	-	146	166
139	255	-	-	-	-	147	166
146	254	-	-	-	-	160	180

[a]Weights taken within three days after calf was removed from metabolism stall.

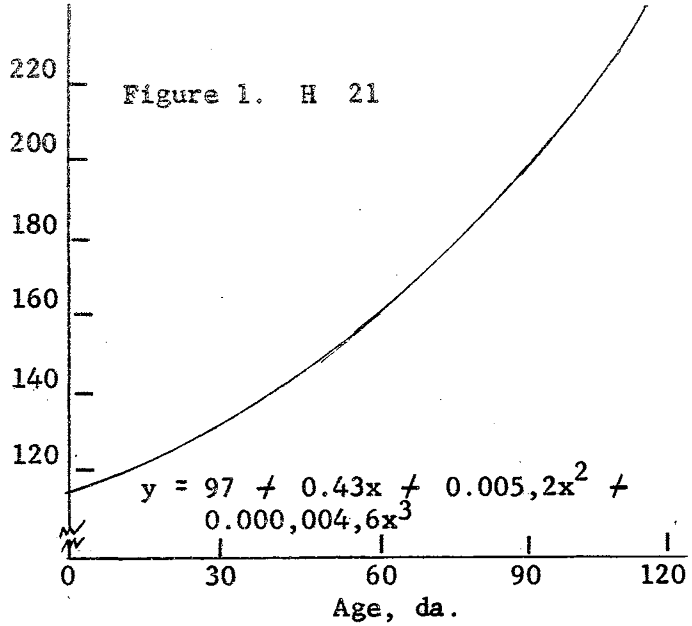
TABLE XII

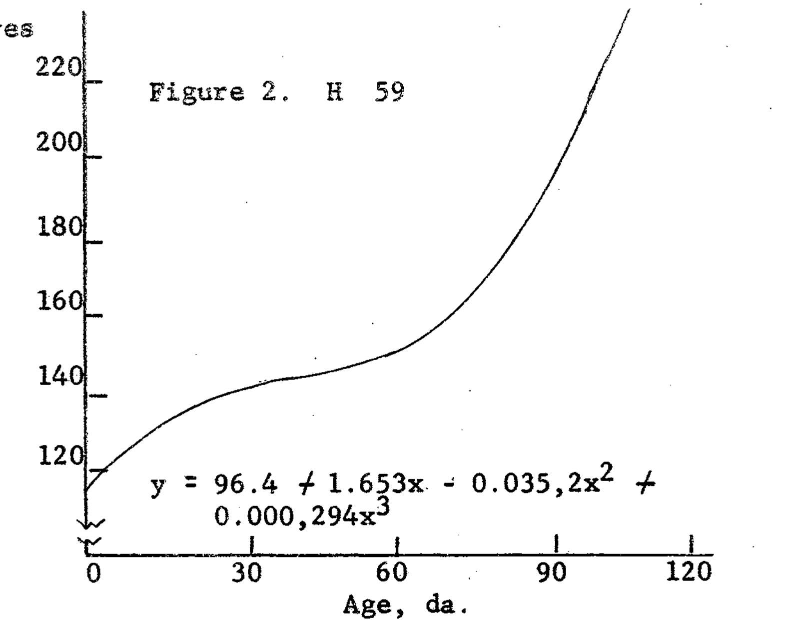
LIVE WEIGHT MEASUREMENTS

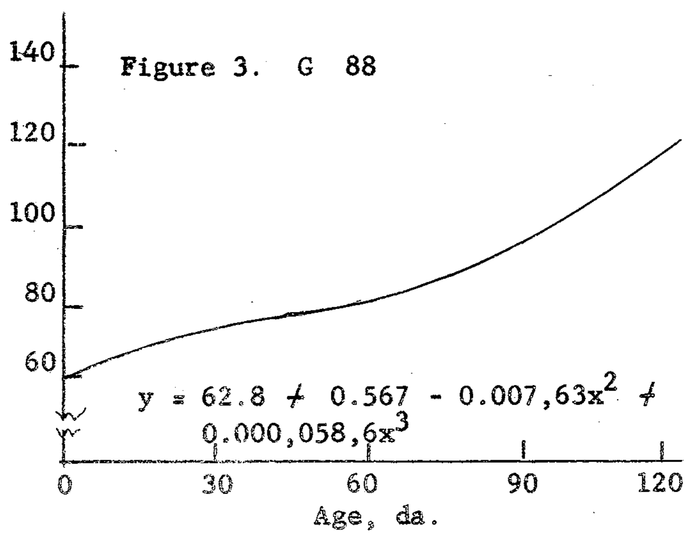
G-112		J-63		A-43		A-49	
Age da.	Lwt. lb.	Age da.	Lwt. lb.	Age da.	Lwt. lb.	Age da.	Lwt. lb.
0	75	0	65	0	70	0	50
2	85	2	68	2	66	6	47
5	80	5	59	13	68	13	50
13	76	12	57	14	73	15	52
14	77	19	60	15	72	16	50
15	77	20	60	22	75[a]	23	53[a]
16	75	21	60	23	82[a]	24	51[a]
23	77[a]	22	60	25	78	25	56[a]
24	83[a]	31	61[a]	29	81	34	57
33	87	32	60[a]	36	87	36	56
34	87	33	60[a]	38	87	37	60
42	86[a]	40	65	39	87	47	56
43	88[a]	47	68	40	85	54	58
44	89[a]	48	68	49	90	61	60
46	92	49	68	57	98	68	66
50	90	50	70	58	96	75	70
51	90	51	72	65	102[a]	82	76
53	92	58	79[a]	71	115	-	-
61	94	61	76	72	112	-	-
67	98	65	80	81	112[a]	-	-
68	96	66	82	82	120[a]	-	-
75	100[a]	67	81	85	118	-	-
76	102[a]	74	85[a]	89	122	-	-
77	104[a]	75	82[a]	90	138	-	-
82	110	76	94[a]	91	136	-	-
88	116	77	95	100	138[a]	-	-
90	110	89	108	101	144[a]	-	-
91	120	90	106	102	153[a]	-	-
92	119	91	108	113	154	-	-
103	120[a]	101	108[a]	114	160	-	-
104	122[a]	102	106[a]	115	157	-	-
105	130[a]	103	116[a]	125	168[a]	-	-
117	138	110	128	126	162[a]	-	-
118	138	117	132	127	170[a]	-	-
119	142	119	132	141	182	-	-
129	144[a]	120	136	-	-	-	-
130	144[a]	121	137	-	-	-	-
131	154[a]	122	138	-	-	-	-
138	169	132	130[a]	-	-	-	-
145	168	133	143[a]	-	-	-	-
-	-	134	134[a]	-	-	-	-

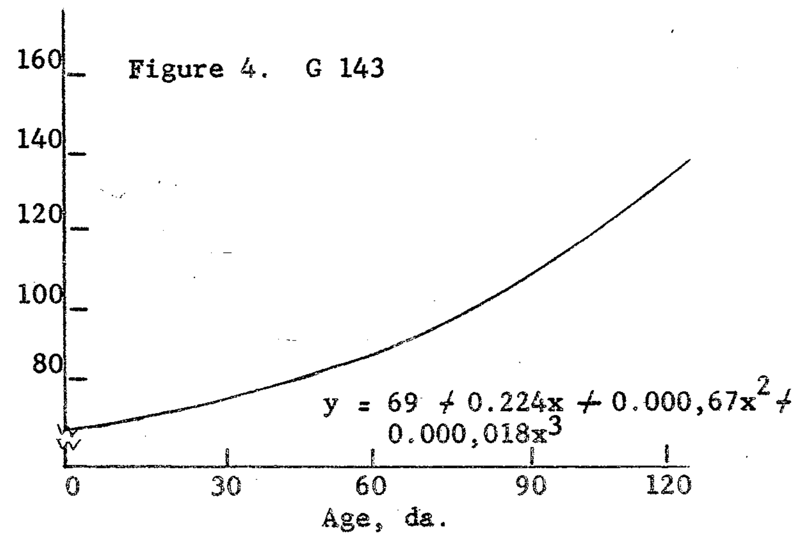
[a]Weights taken within three days after calf was removed from metabolism stall.

Growth Curves

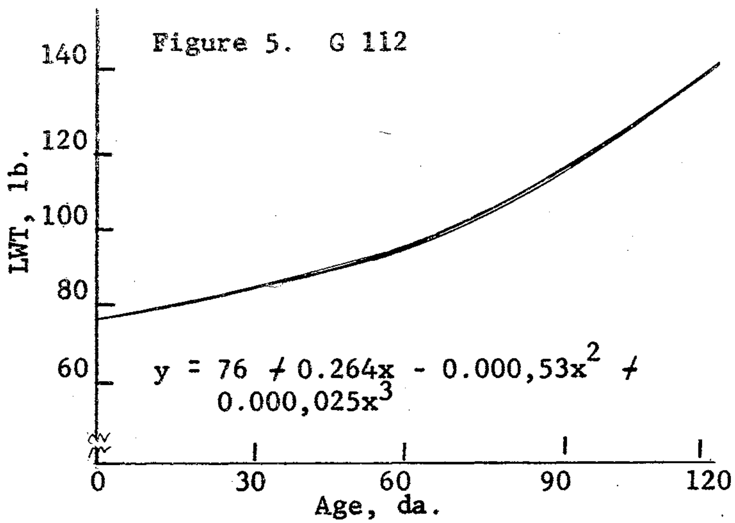


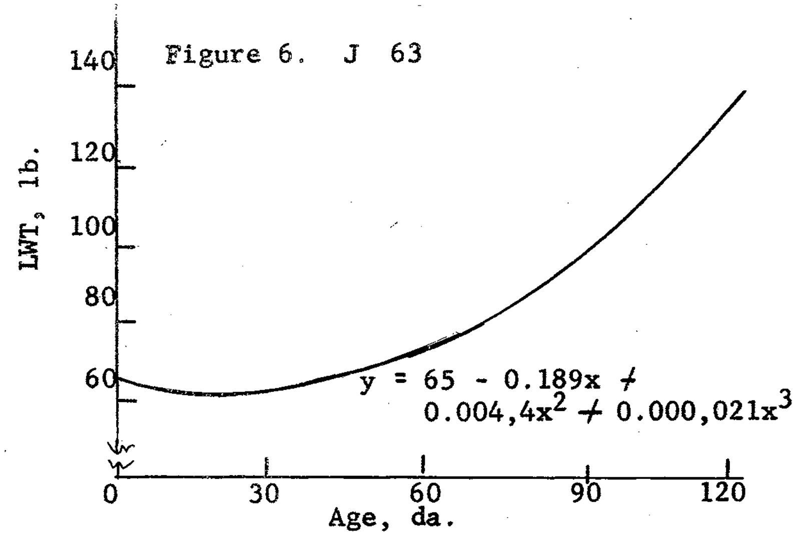


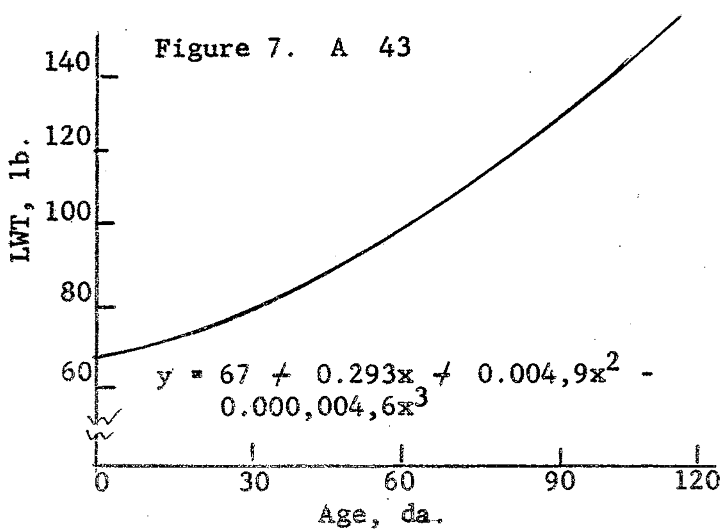


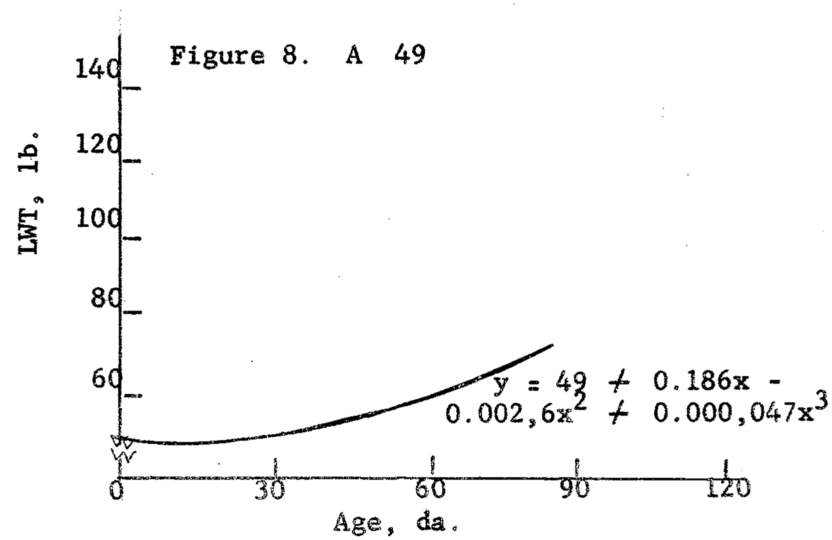


Growth Curves









VITA

JACK L. GRIFFITH

Candidate for the Degree of

Master of Science

Thesis: PROTEIN REQUIREMENTS OF DAIRY CALVES: NITROGEN RETENTION AS RELATED TO LIVE WEIGHT AND AGE

Major: Dairy Production

Biographical:

Born: April 1, 1930, Roff, Oklahoma.

Undergraduate Study: Murray State School of Agriculture 1948-50; Oklahoma A & M College 1953-55.

Graduate Study: Oklahoma A & M College 1955-57.

Experience: Army of United States 1950-51. Employed by Oklahoma Gas and Electric Co. 1951-1953.

Member of: American Dairy Science Association, Red, Red Rose, Phi Sigma Society, Alpha Zeta, Reserve Commissioned Officer of Army of United States, National Guard Association of United States, Oklahoma National Guard Association.

Date of Final Examination: May , 1957

THESIS TITLE: PROTEIN REQUIREMENTS OF DAIRY CALVES: NITROGEN RETENTION AS RELATED TO LIVE WEIGHT AND AGE

AUTHOR: Jack L. Griffith

THESIS ADVISER: Dr. Magnar Ronning

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