# A STUDY OF A SIMPLIFIED DRY FED GRAIN MIXTURE FOR RAISING DAIRY CALVES

THESIS FOR THE DEGREE OF M. S.

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THESIS

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# A STUDY OF A SIMPLIFIED DRY FED GRAIN MIXTURE FOR RAISING DAIRY CALVES.

Thesis

Respectfully submitted to the Graduate School of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of Master of Science.

By

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1931

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# INTRODUCTION

Dairy herd improvement should begin with the careful selection of heifer calves that are suitable to be raised for herd replacement purposes. At present there are approximately 901,000 dairy cows over two years of age in Michigan. Considering that six years is the average life of a dairy cow about 180,000 dairy heifers must be raised annually to maintain the present dairy cow population. Economical herd improvement is possible only under conditions where discarded cows are replaced by well grown heifers of improved breeding and type.

The dairyman who maintains his herd by purchasing cows for replacement purposes finds it extremely difficult to improve or even maintain his present level of production unless he is willing to pay a premium for animals with high production records. Furthermore, he is confronted with the possibility of introducing diseases into the herd such as tuberculosis, Johne's disease, and more especially, contagious abortion.

Few calves are raised in whole milk areas. Fluid milk is usually worth more in market milk channels than it is as a calf feed. Therefore, it is necessary to develop a satisfactory system using a minimum of milk before much progress can be made in herd improvement in whole milk areas.

The purpose of this study was to investigate two systems of raising calves on minimum amounts of milk which might be used to advantage by dairymen in whole milk areas. The minimum milk system widely advocated by the New Jersey Experiment Station and a similar system in which skim milk powder was supplemented with grains were used in this investigation.

## REVIEW OF LITERATURE AND GENERAL DISCUSSION

To be successful, a system of raising calves must not only be economical but must produce healthy animals normal for the breed by the time of the first parturation. Normal growth of any animal depends upon the proper relationship of the external and the internal factors, or the effect of nutrition and environment upon the inherent stimulus.

### GROWTH

Webster defined growth as the progressive development of an organism or member from its earliest stages, accompanied usually by an increase in size with the approach of maturity. Growth as defined by Armsby (1), consists of an increase of the structural elements of the body, chiefly by cell multiplication, resulting in a gain in size and weight.

The more generally accepted definition of growth is given by Eckles (2). He stated that it is understood to include that series of changes in size and structure by which an individual of any species develops from the fertilized egg to maturity. Mendel (3) conveyed the same idea when he said that growth involves that series of physiological changes by which an individual of any species develops from the fertilized egg to maturity.

Thinking in terms of Chemistry, Robertson (4) stated that

growth is the synthesis of a variety of chemical compounds in due proportion and succession to one another. Child (5), also a chemist said that "growth is not a simple chemical reaction and cannot be considered as such; it is a complex physico-chemical process in which changes in the physical character of the substratum as well as chemical conditions are concerned."

Growth Impulse

Growth is a familiar process but a complicated procedure, the solution of which is far from being solved. It is a force that is set in operation upon the fertilization of the egg and persists through a definite phase of the animal's life. This inherited impulse makes it possible to attain a certain size, and even the greatest intake of food will not cause this limit to be exceeded. (6) Minot (7) stated that the growth impulse is derived from the union of the generative cells.

Several experimentors (8), (9), (10), (11) and (12) found that the growth tendency is more noticeable in the skeleton than in other parts of the body. They found that if an animal fasts, the skeleton grows at the expense of the rest of the body, the fatty tissues being used first and the other tissues later, since the most important ones are also the more resistant.

Eckles (13) influenced the rate of growth and, to a certain extent, the size of the animals by feeding heavy and light rations. The animals fed a heavy ration reached maturity earlier and were slightly heavier than those fed a light ration.

Lush (14) explained the results obtained by Eckles by

stating that "in the normal development of young of the same age and species, a definite percentage of the energy content of the blood is required for growth irrespective of the size of the individual." The energy content of the blood of animals fed a heavy ration is no doubt higher than the energy content of blood of animals fed a light ration, thus causing them to grow faster and to reach maturity at an earlier age.

Kellicott (15) stated that in organisms in general the normal growth of each tissue or of each organ is controlled separately by a specific internal secretion. The substance may regulate growth either through inhibition or acceleration, and the effect produced may be due either to the presence or the withdrawal of the specific substance. He attributed the secretion of these specific substances to the glands of internal secretion. While functions of these glands are not definitely known, scientists are slowly solving their mysteries. Recently scientists (16) have isolated and definitely identified a growth promoting substance or "hormone" located in the anterior lobe of the pituitary gland. The discovery of many secondary hormones through which this "central hormone" works will no doubt follow.

Factors Affecting Growth

Normal growth is affected by either internal or external factors. The latter are the only factors under the control of man. Of the external factors, nutrition (6), (10), (17), (18) and age of breeding are the most important. Eckles and Swett

(6) found that a combination of early calving and light rations during the growing period are the main causes for the majority of undersized cows.

Thompson and co-workers (18) and Osborne and co-workers (19) found that following a period of suppressed growth, gains are made with a smaller intake of food than is required during a period of equal growth at a normal rate from the same initial body weight.

<u>The Period of Maximum Growth</u>

Brody (20) stated that the "time-rate" of growth declines at a constant rate which is principally a genetic characteristic of the given animal and to a small extent a result of environment. He also stated that growth consists of two periods, namely: "The self-accelerating phase" or the period in which growth increases with the increase in the size of the animal, and the "self-inhibiting phase" or the period in which the "time-rate" of growth decreases as the size of the organism increases.

According to Minot (7), a rabbit grows 1000 per cent the first day of uterine life. However 98 per cent of the growth impulse is lost before birth. An animal then begins ex-uterine life with less than 2 per cent of the original growth power with which it was endowed.

The work of Mumford (21) with dairy cattle indicates that about 50 per cent of the growth in height at the withers takes place in utero but only about 7 per cent of the growth in weight takes place during the same period. He also found that the maximum rate of ex-uterine growth in both height and weight is realized when the animal is from 5 to 20 months of age. Growth in height at withers practically ceases when the animal reaches 30 months of age but there is an increase in weight for a much longer period of time.

## Measurement of Growth

Growth can be measured by body weight, height at withers, or by body weight and height of the animal.

With any method used in measuring growth of cattle, it is necessary to know what constitutes normal for a given breed and then compare the measurements taken, with the normal.

Eckle's (22) normal for Holsteins, Jerseys, and Ayrshires is the most widely used normal growth standard. He considered both weight and height, from birth to maturity and presented his data in the form of a curve for each.

## Colostrum

The health and growth of calves depends on the start given them shortly after birth. The first and most important contributary factor in this respect is to make sure that the calf gets a good feed of colostrum within the first few hours of post-natal life.

Colostrum is the yellowish, sticky fluid, rich in protein and containing large numbers of cells, secreted the last days before and immediately after parturation. It differs from normal whole milk in chemical, physical, and biological properties (23).

Chemical Properties. Colostrum differs from whole milk as shown below (24).

| | Colostrum Per Cent. | Normal Milk Per Cent. |
|---|---|---|
| Water | 73.07 | 87.27 |
| Casein | 2.65 | 2.95 |
| Albumin | 16.56 | 0.52 |
| Fat | 3.54 | 3.66 |
| Lactose | 3.00 | 4.91 |
| Ash | 1.18 | 0.69 |

Eckles (25) also found that colostrum is lower in water, sugar, and fat and higher in casein, albumin and ash than whole milk. He (25) stated that "the albumin content often reaches 15 to 16 per cent."

Several other investigators (26), (24a), (27) and (23a) reported the same variation in composition.

According to Ragsdale and Boyd (26), associates of Rogers (24a), Crowther and Raestrich (27), Nelson (28), Smith and Little (29), Famulener (30), and Wells and Osborne (31) the globulin of colostrum is similar if not identical to blood serum. They refer to it as serum globulin thus implying the similarity.

Heineman (23a) in describing colostrum stated that it has a strong odor, bitter taste, is more yellow than normal milk, has an acid reaction, and thickens when boiled because of the coagulation of the albumin.

Physical Properties. Heineman (23a) found that fat globules in colostrum were relatively large but that they rapidly diminished in size when normal milk was secreted. He (23a) reported that the specific gravity ranged from 1.030 to 1.059 as compared to 1.027 to 1.034 for normal milk.

Prati (32) stated that the cell content is extremely high and variable at first, but rapidly decreases with the onset of normal milk secretion. He found four classes of cells always present in varying numbers. 1. Leucocytes, consisting of lymphocytes, large mononuclear leucocytes, and neutrophiles. 2. Anucleated elements or the polychromatics. 3. Glandular epithelial elements, few in number, containing fat droplets of varying size. 4. Macrocytes or extremely large cells round or irregular cytoplasmic contour known as "Colostrum Corpuscles." Their nuclei are central or eccentric in position and stain violet, red or blue.

He is of the opinion that the term "Colostrum Corpuscles" should be discontinued and the colostrum be regarded as a concentrated type of milk.

The leucocytes are normal constituents of the interstitial tissue of the mammary gland even in the resting condition. During gestation they increase, and during lactation they accumulate in the vicinity of the alveoli.

The anucleated elements represent parts of the glandular epithelium with which the fat globules have surrounded themselves before desquamation. The desquamated products are epithelial cells, including the "Colostrum Corpuscles."

<u>Biologic Properties</u>. Traum (33) stated that it was gener-

ally taught that colostrum acts as a laxative, and is nature's provision for aiding the elimination of deletarious gastro-intestinal contents of the newborn.

The early work of Howe (34) indicated that colostrum was not entirely laxative to the newborn, although its ingestion did not delay excretion as did milk feeding.

Woodman and Hammond (35) after reviewing the literature, concluded that colostral globulin is a leakage of the serum globulin from the blood vessels. Smith (36), Ragsdale and Boyd (26), associates of Rogers (24a), Crowther and Raestrich (27), Smith and Little (30), and Wells and Osborne (32) found that globulin of colostrum is similar if not identical with blood serum.

Famulener (31) was the first to discover the most important function of colostrum. He found that it is the chief agent in bringing about passive immunization in the suckling. The anti-body content in the blood serum of sucklings is absent at birth but soon appears after suckling. Later Nelson (29) verified his findings and showed that it posessed a bacteriolytic action for B. Coli.

Smith and Little (30) working on the significance of colostrum and the substitution of serum for colostrum found that twelve out of thirteen calves fed colostrum survived, while only four out of fifteen survived when it was withheld. Of the serum treated calves two out of five survived when the serum was injected into the jugular vein, and three out of five when it was fed in the milk. When both treatments were used, all five animals survived.

These workers also found that B.Coli was always the predominating organism in the intestinal tract of calves dying from incomplete or absence of protection from either serum or colostrum. Upon further investigation they (37) found that the same bacterial flora were always present, and in addition, scelerosis of the kidneys, transitory joint troubles, and rhinitis may be present in calves not fed colostrum.

Later Smith (38) and Smith and Orcutt (39) working on the bacterial flora and their location in the intestines divided the small intestines into five and six segments, from anterior to posterior, of 10 to 12 feet each. They found the greatest concentration and change in the fifth and sixth segments. These investigators (39) later found that B. Coli were always present in the lower and not the upper segments of the intestine. With the onset of scours, B. Coli were present in greater concentration in the lower segments with rapid spreading into the upper segments. When death resulted, the entire length of the small intestine was flooded with B. Coli. These workers concluded that there is a delicate balance between the mucaus membrane of the digestive tract and certain strains of B. Coli which is set in operation upon the ingestion of colostrum. When this balance is upset scours follow and death willresult unless the balance is restored.

Smith (40) found that nephritis like multiple arthritis is a result of bacteremia brought about by the incomplete or absence of colostrum protection.

Also Smith and Little (41) and Howe (42) found that colostrum feeding caused proteinurea. They found this condition to last until the fourth day or as long as colostrum ingestion lasted. These investigators were able to prolong proteinurea to the sixth day by the introduction of fresh colostrum.

Howe (42) also found that high protein content of the feces of young calves during the first few days was due to the ingestion of colostrum.

It is apparent that colostrum is a necessary food for the newborn calf. It differs from whole milk in chemical, physical and biological properties. It is lower in water, sugar, and fat content and higher in casein, albumin and ash content, and aside from this, experimentors have found the globulin of colostrum to be identical with the globulin of the blood.

The cell content is considerably higher than that of normal milk and is especially rich in "Colostrum Corpuscles" and disquamated epithelial cells.

The functions of colostrum are two-fold, namely: Laxative effect and the means through which antibodies are transferred in the globulin portion to the young animal, thus creating a delicate balance between the animal body and invading organisms, especially against B. Coli in the digestive tract.

Protein Requirement for Growth

The proteins are a class of complex chemical compounds made up of amino acids, some of which are absolutely essential for life and its processes. They are found only in living matter or the products of the action of living matter (43) and are always associated in common feeds in varying proportions with carbohydrates and fat. Proteins constitute a greater part of the animal tissue solids, while in plants carbohydrates and fat constitute the major part. For this reason the general opinion of nutritional investigators and livestock feeders has been that they play a predominant role in the processes of animal life and are therefore of major importance in nutrition.

The work of Rubner and Heubner (44) confirmed by Mendel and Osborne (56) suggested that growth is not proportional to the quantity of protein in the diet. They found that as the amount of protein is increased a smaller percentage is utilized for growth and the excess of the intake is merely consumed in place of an equivalent of non-nitrogenous food.

Osborne and Mendel (45) stated that "the relative values of the different proteins in nutrition are based upon their content of those special amino acids which cannot be synthesized in the animal body and which are indispensible for certain distinct, as yet not clearly defined processes which we express as maintenance or repair."

Mathews (43a) stated that "animals cannot make sufficient tryptophane, tyrosine, lysine, and cystine to supply their needs, but that these amino acids must be present in the diet."

Hawk and Bergheim (46) in their discussion of amino acids listed the following as being essential for normal growth; Lysine, tryptophane, cystine, and tyrosine, and that possibly histidine and proline are also necessary.

Tryptophane. Osborne and Mendel (45) fed rats a ration deficient in tryptophane. They showed that this amino acid cannot be synthesized by the animal body and that it is absolutely essential for maintenance and growth. The works of Hogan (47), Totanti (48) and the later work of Osborne and Mendel (49) in feeding rats diets deficient in this amino acid confirmed the results previously obtained by the latter experimentors (45). According to Hicks (50) rats readily lose in body weight when fed diets deficient in tryptophane.

Lysine. Osborne and Mendel (51) maintained a 50 gram rat at almost a constant body weight for 180 days by feeding a diet containing zein as the principle source of protein supplemented with tryptophane equal to 3 per cent of the zein. When lysine was added to the ration normal growth was resumed. They concluded that lysine was not necessary for maintenance.

Hogan (47) fed rats corn as the sole source of protein. He failed to obtain growth without the addition of an adequate supply of lysine. Hogan concluded that lysine was necessary for growth.

Sure (52), Osborne and Mendel (45), (53), (54) and Hart, Nelson, and Pitz (55) also concluded that lysine was necessary

for growth but not for maintenance.

Osborne and Mendel (14) found that the addition of increasing amounts of lysine and tryptophane increased the rate of growth until the normal rate was attained, after which the addition of larger quantities of these amino acids did not increase the rate of growth, which they said was limited by the natural capacity to grow.

Cystine. Osborne and Mendel (51) found that the addition of a 9 per cent level of cystine to casein as the sole protein diet for rats produced normal growth. Woods (57) fed rats a cystine free diet on which they made no gains, but when changed to a normal diet they resumed growth and were able to reproduce normally. Sherman and Merrill (58) found that cystine was the limiting factor in a diet of whole milk powder diluted five times its weight with corn starch and supplemented with yeast.

Lewis (59) showed that the nitrogen balance of dogs fed a low protein diet is favorably influenced by the addition of cystine to the ration. Lewis (60) later fed dogs a casein diet supplemented with cystine and again obtained a favorable nitrogen balance.

Other investigators (14), (52), and (55) also concluded that cystine is essential for normal growth and reproduction.

Arginine and Histidine. Arginine and histidine are closely associated and are considered by some investigators as being interchangeable. Ackroyd and Hopkins (61) found that in metabolism, an animal is able to convert one into the other and that the presence of either one of these amino acids in the ration made it adequate.

Harrow and Sherwin (62), Rose and Cox (63), and Rose and Cook (64) definitely showed that histidine is one of the amino acids absolutely essential for growth and maintenance and that arginine cannot replace histidine in the diet. Sure (65) obtained increased growth in rats fed a diet to which arginine was added.

Tyrosine. Sherman (66) stated that "phenylalanine seems to yield tyrosine in the body and it appears that either tyrosine or phenylalanine must be fed."

Totanti (48) fed rats a diet deficient in tyrosine and found that it did not prevent growth and therefore was not necessary in the ration. He also said that if tyrosine was necessary for maintenance and growth, "phenylalanine seems able to act as raw material for its formation."

Lightbody and Kenyon (67) also fed rats a ration deficient in tyrosine and found that it was not essential for growth. These investigators cited work done by Abderhalden, where he found that dogs readily lost weight when fed a ration deficient in tyrosine. However when it was added to the ration, they gained in weight.

Proline. Sure (65) found that the addition of proline to a protein-free diet resulted in increased growth. Sure (68) also stated that "proline is present in considerable amounts in most proteins, it was not found possible to feed a ration entirely deficient of it, with the aim of ultimately making proline additions and noting the resultant improvement in the growth of the animals."

It appears from the review of literature that tryptophane, cystine and histidine are essential for maintenance and growth; that tyrosine is essential for maintenance; that lysine is essential for growth. There is apparently very little danger of feeding a proline deficient ration. It also appears that arginine and histidine are not interchangeable and that arginine and proline may be essential for maintenance and growth.

Energy Requirements.

There is very little known about the energy required for a growing calf. Armsby (1a) found that 1.2 pounds of protein per 1000 pounds live weight are sufficient for maximum possible protein gain.

Armsby (69) developed the Armsby feeding standard. He determined the net energy values of eight typical feeds and of two concentrates. Armsby then used these values and the starch values obtained by Kellner as the basis for estimating the energy in mastication, digestion and assimilation of other feeds. He expressed the energy required of an animal in terms of digestible true protein and therms net energy.

Armsby (1b) compiled the following table of nutrients required per day per head for growth of cattle with no considerable fattening.

Dairy Breeds

| Age Months | Live Weight | Dig. Protein | Net Energy |
|---|---|---|---|
| | Lbs. | Lbs. | Therms |
| 1 | 100 | 0.40 | 3.1 |
| 2 | 135 | 0.45 | 3.4 |
| 3 | 165 | 0.55 | 3.6 |
| 6 | 275 | 0.70 | 4.1 |
| 9 | 325 | 0.75 | 4.4 |
| 12 | 400 | 0.80 | 5.1 |
| 18 | 550 | 0.85 | 6.4 |
| 24 | 700 | 0.85 | 7.6 |
| 30 | 800 | 0.85 | 8.2 |

Eckles and co-workers (70) found that the net energy required to maintain a dairy hiefer at a normal weight is 90 per cent of that set forth by Armsby.

There are two serious objections to the Armsby feeding standard. First, the net energy is not known for all feeds, and second, the energy requirement for growing dairy animals was calculated and is not the amount actually required.

The Morrison Standard (69a) is a modification of the Wolf-Lehman Standard. It is based on a chemical analysis of the given feeds. Morrison obtained the energy required for growing dairy by revising the requirements set forth in the Kellner, Armsby, and Pott standards. The requirements are expressed in pounds of digestible crude protein and total digestible nutrients. The requirements for growing dairy cattle according to the Morrison standard are listed in the following table (69b).

| Animal Growing Dairy Cattle | Dry Water Lbs. | Dig. Cr. Protein Lbs. | T. D. N. Lbs. | Nutritive Ratio. |
|---|---|---|---|---|
| Weight | Lbs. | Lbs. | Lbs. | Lbs. |
| 100-200 | 22.0-24.0 | 2.9-3.2 | 17.0-19.0 | 4.5-5.2 |
| 200-300 | 23.0-25.0 | 2.6-2.9 | 16.5-18.5 | 5.2-5.9 |
| 300-400 | 24.0-26.0 | 2.3-2.6 | 15.5-17.5 | 5.9-6.5 |
| 400-500 | 22.0-25.0 | 2.0-2.3 | 14.5-16.5 | 6.3-6.8 |
| 500-600 | 21.5-24.5 | 1.8-2.0 | 13.8-15.8 | 6.5-7.0 |
| 600-700 | 21.0-24.0 | 1.7-1.9 | 13.0-15.0 | 6.6-7.2 |
| 700-800 | 20.5-23.5 | 1.6-1.8 | 12.2-14.2 | 6.7-7.3 |
| 800-900 | 20.0-23.0 | 1.5-1.7 | 11.4-13.4 | 6.9-7.5 |
| 900-1000 | 20.0-23.0 | 1.3-1.5 | 10.6-12.6 | 7.0-7.6 |

Fitch and Lush (71) criticized the Morrison standard because the protein requirement of an animal weighing near the upper limit of a given class is higher than the requirement for an animal weighing near the lower limit of the next higher class.

Water Requirement.

The water requirement of the growing calf is not known.

Roughage Necessary for Normal Growth

Davenport (72) found that it was impossible to grow calves without roughage. Reed and Huffman (73) also found that calves deprived of roughage died with convulsions soon after three months of age. They found that hay or grass furnishes a factor or factors essential for the development of healthy calves.

The results obtained by Curtis (74) and McCandlish (75) on raising calves on milk alone and Olsen (76) using self feeders for raising dairy calves, confirm the findings of Davenport (72) and Reed and Huffman (73).

Mineral Requirements

The minerals, calcium and phosphorous, are found in all of the body fluids, in the fleshy parts, but in the largest

amounts in the skeleton. These two elements constitute about 90 per cent of the mineral matter of the body (77).

Henry and Morrison (69c) stated that the mineral matter of a fat calf, per 1000 pounds weight, was 16.46 pounds of lime, 15.35 pounds of phosphoric acid, 2.06 pounds of potash and 0.79 pounds of magnesia.

Henry and Morrison (69d) recommended that rations for growing animals should contain three times as much calcium and phosphorous as the animals are storing daily.

Eckles and Swett (6) found that a Jersey heifer fed a ration low in calcium and phosphorous made growth equal to a heifer fed a ration containing approximately three times as much calcium and phosphorous. The heifer on the low mineral ration developed a stiffness at 18 months of age.

Solmon and Eaton (78) fed each of four dairy heifers two ounces of bone meal daily. They found that there was apparently no beneficial effects from the addition of the bone meal to the ration.

Reed and Huffman (79) fed five growing dairy calves a ration of whole milk to sixty days, then skimmilk supplemented with equal parts (by weight) of corn and oats to six months of age, when a ration of timothy hay, silage and a grain mixture of three parts ground yellow corn, one part ground oats, one part cottonseed meal and one per cent salt was fed. The results indicated that there was sufficient calcium and phosphorous in these rations to produce normal growth, good reproduction, and liberal milk production. The addition of steam bone meal did not materially affect growth. However there was a slight difference in favor of this group in both weight and height of withers at five years of age.

According to Reed and Huffman (80), roughages are high in calcium and low in phosphorous while concentrates are high in phosphorous and low in calcium.

They listed the common dairy feeds which are high, medium and low in calcium as follows:

| Feeds high in calcium | pounds per ton |
| --- | --- |
| Bone flour | 479.8 |
| Cow pea hay | 36.3 |
| Soy bean hay | 24.6 |
| Clover hay | 22.8 |
| Alfalfa hay | 20.9 |
| **Feeds medium in calcium** | |
| Beet pulp (dry) | 13.2 |
| **Feeds low in calcium** | |
| Corn | 0.2 |
| Wheat | 1.0 |
| Wheat middlings | 1.9 |
| Oats | 2.0 |
| Wheat bran | 2.5 |
| Timothy hay | 3.5 |
| Wheat straw | 4.1 |
| Gluten feed | 4.9 |

| | |
|---|---|
| Cottonseed meal | 5.3 |
| Linseed oil meal | 7.2 |
| Corn stover | 9.4 |

They also present a similar table showing the high, medium and low phosphorous content of the common dairy foods.

| Feeds high in phosphorous | Pounds Per Ton |
|---|---|
| Bone flour | 298.8 |
| Cottonseed meal | 27.0 |
| Wheat bran | 22.2 |
| Wheat middlings | 17.5 |
| Linseed oil meal | 14.1 |
| Soy beans | 11.8 |
| Gluten feed | 10.8 |
| Feeds medium in phosphorous | |
| Oats | 7.9 |
| Wheat | 7.5 |
| Navy beans | 7.3 |
| Corn | 5.2 |
| Feeds low in phosphorous | |
| Wheat straw | 0.7 |
| Beet pulp (dry) | 1.2 |
| Corn stover | 1.9 |
| Timothy hay | 2.3 |
| Clover hay | 3.4 |
| Alfalfa hay | 4.4 |

Young calves obtain sufficient calcium and phosphorous from whole milk or skimmilk, since both are rich in these elements.

It appears from the review of literature that calcium and phosphorous are indispensible for growth. However if the growing calf consumes a sufficient amount of feeds rich in these elements, there is no need to add to the ration a mineral supplement containing calcium and phosphorous.

Calves raised on a minimum milk system do not consume enough grain or roughage to supply the sufficient minerals for normal growth during the period in which they are transferred from milk or skimmilk to a dry grain ration, thus making it necessary to add a mineral supplement containing calcium or phosphorous to the grain mixture.

VITAMINS

Besides the previously mentioned elements essential for growth there are certain vitamins that are also essential for maintenance and growth of dairy cattle.

Willaman (81) defined them as being "substances whose presence is necessary for normal metabolism but which do not contribute to the requirements of the organism as regards inorganic constituents, nitrogenous substances, and energy producing food constituents." Lush (14a) stated that the name "Vitamin is now commonly used to express the group of as yet unidentified substances which at present cannot be classified with the familiar nutrients, proteins carbohydrates, inorganic salts, and water, but upon which the hormonious behavior of the organism depends and which are ordinarily injested in traces in the food." Mathews (43b) referred to vitamins as the "accessary food substances."

The number of these substances in existance is unknown. Seven or eight have been definitely recognized and designated by letters of the alphabet.

## Vitamin "A"

Necessary for Growth. This vitamin is absolutely essential for normal metabolism and growth. Burrows and Jorstad (82) concluded from their work with rats that Vitamin A is one of the essential substances used in the building of intercellular substances of the body, in the storage of fat, and in the funcion of tissue cells.

Pathological Effects of Vitamin A Deficiency. McCollum and Simmonds (83) stated that when animals are restricted to a ration deficient in Vitamin A, they will develop after a few weeks a non-contagious pathological condition of the eyes known as ophthalma. The first noticeable effects of this disease are manifest when the lacrymal gland ceases to produce tears which causes a dry condition of the eyes. As a result of this condition, cornification takes place followed by blindness unless the vitamin deficiency is corrected.

Koessler, Maurer and Laughlin (84) produced an anemic condition in rats fed a ration deficient in Vitamin A. They concluded that blood regeneration cannot take place in the absence of this vitamin from the diet.

Falconer (85) and Stommers (86) found that the changes in the cell and platlet content of the blood are not constant enough to constitute a specific lesion of Vitamin A deficiency in rats.

Osborne and Mendel (87) found calculi of calcium phosphate in the urinary tract of rats fed a diet deficient in Vitamin A. Van Leersum (88) made chemical microscopic examinations of the kidneys from rats fed a Vitamin A deficient diet and found that they showed deposits of calcium in the epithelial cells. He suggested that the calculi found in the bladders of Vitamin A deficient rats originate in the kidney deposits which are washed into the bladder where they increase in size.

Beach (89) produced a condition resembling roup, in chickens fed a ration deficient in Vitamin A.

Effect of Vitamin A Deficiency on Disease Resistance and Length of Life. Sherman and Burtis (90) found that rats fed a Vitamin A deficient diet were much more susceptible to infection than those fed a diet containing this vitamin.

Sherman and MacLeod (91) found that rats fed a ration deficient in Vitamin A lived only half as long as rats fed an abundance of Vitamin A. These investigators also found that when rats were fed such a diet they were especially susceptible to lung diseases, particularly pneumonia.

Distribution. Steenbock and Bontwell (92) thought that Vitamin A is associated with the yellow pigment of corn. Steenbock and Gross (93) found that green alfalfa plants contain relatively large amounts of the fat soluable vitamin. They concluded that Vitamin A production is closely associated with chlorophyl formation.

Jones, Eckles and Palmer (94) reported that any good quality roughage contains Vitamin A.

The Role of Vitamin A in the Nutrition of Calves. Jones, Eckles and Palmer (94) found that Vitamin A is indispensible for the normal growth of calves. Eckles (2a) stated that "almost any mixture of feeding stuffs will be low in Vitamins A and C."

From the review of literature it appears that Vitamin A is indispensible for maintenance and growth of most all animals.

Animals fed diets deficient in Vitamin A are more susceptible to infection, especially lung diseases and pneumonia than animals fed rations adequate in this vitamin.

Rats fed a diet deficient of Vitamin A lived about half as long as those fed an abundance of this vitamin.

Vitamin "B"

Eckles and co-workers (95) fed calves from 20 to 180 days of age on rations in which the Vitamin B content was supplied in the form of dried yeast. They observed no definite effect on the health of the calves.

Later Eckles and Williams (96) fed cows a ration low in Vitamin B and obtained results equal to those in which yeast was supplemented. They concluded that cattle do not require Vitamin B in the ration.

Bechdel (97), (98), (99) raised 11 calves from birth to first calving on a Vitamin B deficient ration. These animals showed normal growth and reproduction. Bechdel explained his results by stating that probably bacteria and micro-organisms in the digestive tract synthesized Vitamin B.

Later Bechdel and co-workers (100) definitely showed that cattle synthesize their own needed supply of Vitamin B through bacterial synthesis in the rumen.

From the review of literature it appears that Vitamin B is synthesized by bacterial action in the digestive tract of cattle and need not be supplied in the ration.

Vitamin "C"

Honeywell and Steenbock (101) found that Vitamin C is synthesized in considerable amounts during the germination of barley kernels, even when they are germinated in the dark.

Thurston, Eckles and Palmer (102) and (103) grew four calves normally for one year on a ration which produced scurvy in guinea pigs in 20 to 30 days. Normal gestation and parturation occured when a hiefer was fed from birth on a Vitamin C deficient ration. Appreciable quantities of Vitamin C were found in her milk. It was concluded that Vitamin C, like Vitamin B is synthesized in the body but from all indications the digestive tract is not concerned in this synthesis.

## Vitamin "D"

This vitamin is known as the anti-rachitic vitamin or the factor which influences the deposition of minerals in the bones.

Sources of Vitamin D. The common source of Vitamin which is practical for dairymen is good hay, legumes in particular. This vitamin is also found in cod liver oil, sunlight, and ultra violet light. The cost of supplying it in the form of ultra violet light is prohibitive under ordinary conditions.

Vitamin D Content and Method of Curing Legumes. Hart, Steenbock and co-workers (104) found that green alfalfa was somewhat superior to cured alfalfa in maintaining the calcium balance in milking cows.

Russel (105) fed rats alfalfa hay artificially cured out of the sunlight and found that it contained much less Vitamin D

than similar hay cured in the sunlight. He also found that the Vitamin D content of the artificially cured hay was increased upon exposure to ultra violet light.

Steenbock, Hart and co-workers (106) cured hays by three different methods in testing their anti-rachitic properties. The three types of hays used were cured by; (1) drying in the dark on the floor of an attic with a fan; (2) drying in diffused light in the laboratory and then exposed to the weather and sunlight for 14 days; (3) hay was allowed to lie in the field exposed to sunlight, dew and rain for 14 days. When these hays were fed with rachitic producing diets, the one cured in the dark was ineffective in preventing rickets. The hay cured in diffused light and then irradiated with an ultra violet light from a quartz mercury vapor lamp proved to be effective. The hay cured in direct sunlight and exposed to rain and dew was partially effective in preventing rickets.

Hart, Steenbock and co-workers (107) found that hays cured in Colorado where there is an abundance of sunlight were no more effective in maintaining positive calcium balances in heavy lactating cows than hays cured under Wisconsin conditions where there is less sunlight.

Jost and Koch (108) stated that rickets is a very common disease among pigs, puppies, lambs, and kids, but is less common among colts, calves, and rabbits.

Falkenheim (109) observed that rats exposed to quartz lamp irradiation responded by increased growth and bone- calcification. He irradiated a cow fed a vitamin-free ration and found that it had no effect.

From all indications cattle can assimilate Vitamin D only when it is supplied through the ration.

Windaus and Hess (110) who worked with quartz lamp rays suggest that probably ergosteral is the provitamin of Vitamin D.

Rosenheim and Webster (111) after experimenting with quartz rays concluded that the natural parent or precursor of Vitamin D is ergasterol or a highly unsaturated sterol of similar construction, which is converted into Vitamin D by irradiation.

Significance of Vitamin D to Calves. Bechdel and Hill (112) found that calves are susceptible to a Vitamin D deficiency, and such calves have less ash in their bones than those fed a normal ration.

Irradiation. Steenbock and Black (113) found that by irradiating rat rations with the quartz mercury vapor lamp they could activate them and make them growth-promoting and bone-calcifying to the same degree as when the rats were irradiated. They suggested that "both light and the anti-rachitic vitamin may represent the same anti-rachitic agent - possibly a form of radiant light."

Relation of Sunlight to Growth and Development. For centuries sunlight has been known to exert a beneficial or stimulating effect on growth (83a). Investigators have recently found that light does not affect growth in all animals.

Gullickson and Eckles (114) grew calves from birth to two years of age in a darkened room and found that they grew and reproduced normally. They concluded that light had no effect on the growth of dairy hiefers.

Results of the Kansas (115), (116) and the South Dakota (117) stations confirm the results obtained by Eckles and Gullickson.

Huffman (118) found that calves fed a rachitic diet and allowed access to sunlight did not develop rickets but calves fed a similar diet without sunlight developed rickets.

From the review of literature it appears that the vitamins A and D are essential for growing calves while B and C are not essential.

Since Vitamin D is found in hay cured in the sunlight, there is very little danger of feeding a vitamin D deficient ration, especially when plenty of good quality hay is fed.

## CALF FEEDING

The problem of raising dairy calves was given very little consideration until after the development of the cream separator and the creamery. Then for a number of years the vital question was whether or not skimmilk with supplementary grain feeds could successfully replace part of the whole milk in the ration of dairy calves. Experimental results showed that this system was successful. It became the standard system with most dairymen.

The dairy industry then passed into the fluid milk stage where skimmilk was no longer available on a majority of the farms in whole milk areas. This created an economic problem which finally became one of finding either the minimum amount of milk required to raise a dairy calf, or developing a milk substitute.

Considerable progress has been made in developing minimum milk systems for raising calves, however no satisfactory milk substitute has yet been developed.

Substitutes for Skimmilk

It is generally conceded from experimental evidence that whole milk cannot be entirely replaced in the ration. Observations show that when feeds other than milk are fed to the young calf, digestive troubles develop. There is so little known about the digestive tract of the growing calf that no one knows definitely what changes take place when feeds other than milk are fed. Schalk and Amadon (119) found by making rumen fistulas in young calves that the esophageal groove functions only in the nursing calf and in animals on an exclusive milk diet. Its edges contract at eating time, forming a tube through which milk drunk at a normal rate, passes directly into the abomasum. When drank rapidly and in large swallows, the groove spreads and lets milk escape into the rumen which may cause digestive trouble due to the undeveloped condition of the rumen. Milk can only be digested in the abomasum. Milk that escapes into the rumen eventually reaches the abomasum, but after some delay during which time fermentation probably takes place.

Buttermilk, Whey and Sour Skimmilk.

Otis (120) fed calves buttermilk and obtained slightly less returns than with skimmilk. He also successfully fed calves whey but found that it had a tendency to cause scours and that gains were slower than when skimmilk was fed. The findings of Morrison and co-workers (121) and Peterson (122) agree with those obtained by Otis.

Eckles and Gullickson (123) and Ellington (124) found that powdered buttermilk when remixed at the rate of 1 pound of powder to 9 pounds of water produced calves which were normal at six months of age. The calves were not troubled with digestive disturbances when care was used in feeding and all changes were made gradually.

Woodward (125) fed calves sour skimmilk. He found that milk fed to calves soon after souring, and when it was always at about the same acidity, did not produce scours or other digestive disturbances after the calves were accustomed to it.

These experiments show that buttermilk, buttermilk powder, whey or sour skimmilk can be successfully fed to young dairy calves when the changes from whole milk or skimmilk to the one used, are made gradually.

Molasses for Calves.

Woodward (126) and Mead and co-workers (127) found that blackstrap molasses was extremely laxative for growing calves. They attributed it to sugar fermentation in the digestive tract.

Conrad (128) claimed to have successfully fed molasses to calves without producing harmful effects. Brentnall (129) found that molasses can be used in the grain mixture as a substitute for corn with calves over two months of age. He stated that it is important that the calf should have free access to water at all times. Galloway (130) added varying amounts of blackstrap molasses to the grain mixture of calves at varying ages and concluded that from one to two ounces of blackstrap molasses can be fed with each feed of grain given daily to calves four weeks or more of age.

It is therefore apparent that molasses may be used as a source of energy in calf rations.

Skimmilk Powder

The associates of Rogers (24b) gave the following as the average composition of separator skimmilk and skimmilk powder.

| | Skimmilk | Skimmilk Powder |
|---|---|---|
| Water | 3.89 | 90.35 |
| Protein | 35.42 | 3.72 |
| Fat | 1.74 | 0.15 |
| Lactose | 48.74 | 4.98 |
| Ash | 8.08 | 0.80 |

Eckles, Combs, and Macy (25a) stated that five per cent moisture is the maximum legal moisture content for skimmilk powder.

Schaars (131) found that the cost of drying buttermilk or skimmilk varies from 2.5 cents to 3.5 cents per pound for the dried product.

Eckles and Gullickson (132) fed re-mixed skimmilk in the proportion of 1 pound of powder to 9 pounds of water and fed it at the same rate as skimmilk is fed. They obtained results equal to those produced by liquid skimmilk.

Other experimentors (133), (134), (135), (136), (137) and (138) obtained results comparable to those of Eckles and Gullickson. These workers also found that skimmilk powder of either the roller or spray process was more economical as a calf feed than whole milk but less economical than liquid skimmilk.

Bechdel (139), Williams and Bechdel (140) and others (133), (134), (135), (136) and (141) fed skimmilk powder in the dry grain ration. They obtained the best results when the dry grain ration consisted of 35 to 40 per cent and not over a maximum of 45 per cent skimmilk powder. They also found

.that the calves should not be changed to the dry grain ration before they are six weeks of age.

Gruel Feeds

Gruel feeding is becoming less popular among dairymen because of the labor involved in the preparation of gruel.

Michels (142) stated that a milk substitute must be "very palatable and digestible, rich in muscle and bone-forming material and contain little crude fiber." He found that 12 ounces of rolled oats cooked in one gallon of water and fed at body temperature gave excellent results.

Hayward (143) developed "Haywards Calf Meal", one of the first and most successful and widely used calf meals of its time. It was composed of the following ingredients:

| | | |
|---|---|---|
| 30 | pounds | flour |
| 25 | " | cocoanut-meal |
| 20 | " | nutrium (S. M. P.) |
| 10 | " | Linseed oil meal |
| 2 | " | dried blood |

This system called for whole milk for 7 to 10 days, then a gruel made by mixing 1 pound of "Haywards Calf Meal" to 6 pounds of water so that by 14 to 18 days of age the calves were fed gruel alone. The change was made gradually.

Maynard and Norris (144) replaced milk at about four weeks of age with a mixture composed of the following materials fed as a gruel:

250 pounds corn meal

| | | |
|---|---|---|
| 250 | pounds | red dog flour |
| 150 | " | ground oats |
| 150 | " | linseed oil meal |
| 100 | " | ground malted barley |
| 100 | " | soluble blood flour |
| 10 | " | precipitated calcium carbonate |
| 10 | " | precipitated bone meal |
| 10 | " | salt |

The gruel was made by mixing one pound of the above mixture with five pounds of water at 100° F. This was fed three times per day. The gruel was supplemented with alfalfa hay and a dry grain mixture consisting of:

| | | | |
|---|---|---|---|
| 30 | pounds | of | hominy |
| 30 | " | " | ground oats |
| 30 | " | " | wheat bran |
| 10 | " | " | oil meal |

Ground and cooked carrots were fed to supply vitamins. These also stimulated the consumption of dry grain. Maynard and Norris found that calves grown by this system made gains equal to skimmilk fed calves. However they did not recommend that this system replace skimmilk in the ration of calves but to be used only where skimmilk was not available.

Davis and Cunningham (145) fed whole milk for 10 days, then whole milk and gruel made by mixing one pound of the following grain mixture to one gallon of water.

| | | |
|---|---|---|
| 2 | parts | corn meal |
| 4 | " | wheat middlings |
| 2 | " | oat flour |
| 1 | " | linseed oil meal |
| .5 | " | blood meal |
| .2 | " | bone meal |
| .2 | " | salt |

Whole milk was replaced at 40 days of age by gruel, alfalfa hay and a dry grain mixture composed of equal parts of wheat bran, rolled barley and linseed oil meal.

These workers concluded that calves fed on this system were more subject to digestive trouble than whole milk or skimmilk fed calves and that they were less thrifty at 2 to 3 months of age than whole milk or skimmilk fed calves but were normal at 5 to 6 months of age. Davis and Cunningham did not recommend this method of raising calves when either whole milk or skimmilk was available.

Morrison and Rupel (146) found the following grain mixture, fed as a gruel was fairly satisfactory.

| | | |
|---|---|---|
| 250 | pounds | corn |
| 250 | " | flour middlings |
| 250 | " | ground oats (hulls sifted out) |
| 120 | " | linseed oil meal |
| 100 | " | soluble blood flour |
| 10 | " | salt |

10 pounds steam bone meal
10 " Wisconsin brimstone

The gruel was supplemented with alfalfa hay and a dry grain mixture composed of :

30 pounds corn
30 " bran
10 " linseed oil meal

The calves raised on this system were normal at six months of age, compared with Eckle's normal.

Rupel (147) later found that a grain mixture composed of equal parts of corn, oats, bran and linseed oil meal, fed in the milk and supplemented with alfalfa hay, produced animals that were normal at six months of age.

Lindsey and Archibald (148), (149) concluded after working with many different calf meals that the method which was most satisfactory, from the standpoint of economy and growth, was a limited amount of remixed skimmilk with a good quality hay, supplemented with the following grain mixture:

30 pounds ground oats
30 " red dog flour
25 " corn meal
15 " linseed oil meal
5 " salt

These investigators recommended that the skimmilk powder be supplemented with a mixture of equal parts of red dog flour and hominy feed when an extra good calf is desired. One and one-half ounces of this grain mixture should be added to one and one-half ounces of skimmilk powder and mixed in one quart of water. Hay was fed in addition to gruel, and the above dry grain mixture.

Hunziker and Caldwell (150) developed the "Purdue Calf Meal" consisting of equal parts of hominy feed, linseed oil meal, red dog flour, and dried blood. They fed it as a gruel made by mixing one pound of the calf meal to seven pounds of water, supplemented with alfalfa hay and equal parts of ground corn and oats, dry fed. Satisfactory results were obtained when the calf was left with the dam for 4 to 5 days, then bucket fed whole milk with the addition of a small amount of the meal when the calf was 7 days of age. The meal was then mixed with water (1 part to 7 parts of water) and increased as the amount of milk was decreased until at seven weeks of age, it was receiving approximately 18 to 20 ounces of meal daily. This rate was maintained constant until the calf was six months of age when it was increased to 24 ounces per day supplemented with equal parts ground corn and oats, alfalfa hay, and a small amount of silage.

Spitzer and Carr (151), (152) found that 12 parts liquid blood, eight parts corn meal, and one part linseed oil meal, fed according to the system followed by Hunziker and Caldwell (150) was slightly inferior to skimmilk. They found that calves fed the "Purdue Calf Meal" made an average daily gain

of 1.18 pounds, as compared to 1.24 pounds for skimmilk and 1.16 pounds for whole milk. They concluded that it was a "successful skimmilk substitute."

Minimum Milk Systems of Raising Dairy Calves

Solun (153) fed calves the same total amount of milk but varied the rate of feeding and the length of the feeding period. He obtained the best results when milk was fed in rather large amounts at younger ages with a gradual reduction of the milk as other feeds were consumed.

Fraser and Brand (154) and Eckles and Gullickson (155) found that when whole milk and skimmilk were supplemented with grain and alfalfa hay, approximately 150 to 170 pounds of whole milk and 350 to 500 pounds of skimmilk were required to raise a dairy calf to six months of age.

Eckles and Gullickson (155) and others (156), (157), (158), (159) found that when whole milk was fed to a calf for 50 to 60 days, supplemented with grain and alfalfa hay, it required 350 to 800 pounds of milk, depending upon the breed and strength of the individual animal. These authorities concluded that milk can be safely removed from the ration when the calves are from 50 to 60 days of age.

La Master and Elting (158) weaned calves from their dams at 60 days of age and then fed the following dry grain mixture:

44 pounds ground oats
40 " ground yellow corn

15 pounds white (Haddock) fish meal

1 " salt

The calves were fed all of the grain they would consume up to a maximum of five pounds daily, supplemented with soy bean hay.

The results of the first experiment were not satisfactory, consequently the second group was fed on the following dry grain mixture:

40 pounds ground oats

39 " yellow corn

10 " white (Haddock) fish meal

10 " skimmilk powder

1 " salt

The calves fed this mixture were also weaned from whole milk at 60 days of age and fed a maximum of five pounds of the grain mixture daily, supplemented with soy bean hay.

La Master and Elting reported that all of the calves grew well and showed no abnormal symptoms, but were slightly below normal at six months of age, although at nine months of age they were normal. The grain mixtures were not as palatable as was desired. The calves did not readily eat these mixtures until about four months of age.

Bond (159) recommended the use of the following dry calf meal supplemented with alfalfa hay and a free access to water:

2 parts (by weight) of linseed oil meal

3 " " " " crushed oats

1 part (by weight) of bran

¼ " " " " fish meal

Ragsdale and Turner (160) showed that calves weaned from milk at 60 days of age were approximately 70 per cent normal in weight at six months of age when fed alfalfa or soy bean hay and the following grain mixture:

4 parts (by weight) corn chaff

1 " " " wheat bran

1 " " " soy bean meal

Mead and co-workers (11) were the first to demonstrate that calves can be successfully raised by weaning from milk to a dry grain mixture and alfalfa hay at 30 to 50 days of age. They fed the following grain mixture supplemented with alfalfa hay:

6 parts (by weight) hominy

6 " " " wheat bran

4 " " " linseed oil meal (o. p.)

4 " " " ground oats

2 per cent salt

2 " " raw rock phosphate

The calves were watered twice daily throughout the experiment. They were below normal in both height at withers and weight at six months of age, but were normal according to the Eckle's normal, at first calving.

Bender and Bartlett (161), (162), (163), (164), (165), (165a), (165b), (166) developed the New Jersey system of rais-

-ing calves. The procedure is as follows: Allowed the calves to suckle until 48 hours of age. The calves were then weaned from the dams and fed a maximum of 3 quarts of milk a day in three feedings per day for the first 10 days, then twice daily until the calves were 30 days of age or a total of approximately 150 pounds. Grain and alfalfa or clover hay were placed before the animals after they were a week of age. When the calves were three weeks old, the milk was reduced by diluting with water so that by the end of 30 days, they were getting the dry-fed mixture, legume hay and fresh water. At 30 days of age, they were eating approximately one pound of grain. These workers stated that six pounds of grain is the maximum amount to feed regardless of breed and age.

When the calves were six months of age, the first grain mixture was replaced by the following grain mixture:

| | | |
|---|---|---|
| 100 | pounds | corn meal |
| 100 | " | ground oats |
| 100 | " | wheat bran |
| 30 | pounds | linseed oil meal. |

The animals were allowed free access to alfalfa hay and water. Silage was also added to the ration after they were six months of age.

Excellent results were obtained with this system. When compared with Eckle's normal, the calves were below normal at six months of age but were 100 per cent normal at nine months of age.

They found that the calves developed a cough soon after being placed on the dry-fed ration, which persisted for most of the six month period. They concluded that it was due to the fineness of the grain ration.

Caine (167) fed calves the following dry grain mixture based on the New Jersey system:

| | | |
|---|---|---|
| 20 | pounds | yellow corn meal |
| 10 | " | wheat bran |
| 20 | " | skimmilk powder |
| 30 | " | ground oats |
| 20 | " | linseed oil meal |
| 1 | pound | finely pulverized bone meal |
| 1 | " | finely pulverized limestone |
| 1 | " | salt |

The calves were approximately 98 per cent normal for height and 92.4 per cent normal for weight at six months of age, when compared with Eckle's normals.

The results of other experimentors (166), (169), (170) indicated that with the nature of the present dry-fed rations the age at which calves are changed from milk to grain cannot be safely lowered below that advocated by the New Jersey system.

Caldwell (168) found that the nitrogen elimination of calves on a ration of milk, ground corn and oats and alfalfa hay, was eliminated equally through the urine and feces. The nitrogen excretion of the calves fed a dry grain mixture was mainly through the feces.

Norris (169) fed calves a cereal-gruel rich in starch. He found that there was a greater production of volatile fatty acids and alcohols in the intestinal tract, on such a ration than with a whole milk ration.

He concluded that calves cannot completely digest rations relatively rich in starch. The undigested food furnishes an ideal media for bacterial growth, which takes place, and is responsible for the production of the fatty acids and alcohols.

Shaw and co-workers (170) fed whole milk and four grams of corn starch per feeding to four day old calves for three successive days followed by a 5 day rest period during which only whole milk was fed. Starch feeding was then repeated for three days. The same procedure was again repeated and the feces were collected and analyzed for both periods throughout the experiment.

These workers found that calves 4 to 7 days of age digest about 20 per cent of the quantity of starch consumed. When 12 to 15 days of age, the amount of starch digested reached approximately 40 per cent of the amount consumed and when three weeks of age nearly 60 per cent of the starch was digested. At four weeks of age, the calves digested more than 90 per cent of the starch consumed.

The experimental results show that the ration of young calves should be restricted to whole milk for a week to 10 days after birth, when a supplementary grain mixture especially rich in starch, may be introduced and the amount fed rapidly increased as the animal grows older.

From the review of literature, it is evident that calf feeds should be listed in the order of their food value as follows; whole milk, skimmilk, skimmilk powder, the successful dry-fed meals, buttermilk, whey, sour milk and molasses.

There is some indication that the reason for the failure of dry-fed meals is because they go to the rumen instead of the abomasum. The rumen in the young calf is undeveloped.

Young calves that are fed a dry grain mixture are subject to a cough that some experimentors think is caused by the fineness of the grain mixture.

There is some indication that calves fed a dry-grain ration and allowed free access to water, make better growth and are less subject to digestive trouble than calves fed a similar ration but not allowed free access to water.

Usually calves which were grown on any ration other than whole milk, skimmilk, or skimmilk powder, were below normal in growth at six months of age, but were normal or above by nine to twelve months of age. They were usually normal in height at both six and nine months of age.

From the review of literature it is apparent that the New Jersey system of raising dairy calves is the most successful minimum milk or dry-fed grain system yet developed.

## DISCUSSION OF THE REVIEW OF LITERATURE

The growth impulse is very persistant. Following a relatively long period of adverse conditions there is a tendency for the animal to recover and make a greater rate of growth per unit intake of food than a similar animal under normal conditions.

Colostrum is essential to the new born calf because it is the media through which antibodies are transferred from the mother to the offspring.

It appears that tryptophane, cystine, and histidine are essential for maintenance and that lysine is essential for growth. It also appears that arginine and histidine are not inter-changeable and that arginine and proline may be essential for maintenance and growth. There is apparently very little danger of feeding a proline deficient ration since this amino-acid is so widely destributed.

Roughage is indispensable in the ration of growing calves.

A number of minerals are essential for growth. However, a ration is more liable to be deficient in calcium and phosphorus than in the other mineral elements. This is because of the large amounts required and the proportions in which they are found. Steamed bone meal is an excellent source of both of these minerals and should be included in the dry grain mixtures fed young calves. However, when plenty of good quality hay, alfalfa in particular, is fed there is apparently no danger of a mineral deficiency.

It appears that vitamins A and D are essential for growing calves. Vitamins B and C are apparently not essential. Experimental evidence indicates that vitamin B is probably synthesized by bacterial flora in the rumen. There is apparently very little danger of feeding a ration deficient in vitamins A and D when plenty of good quality hay is fed.

It is apparent from the review of literature that no satisfactory minimum milk system has yet been developed. However, the most successful system of this type is one that is widely advocated by investigators of the New Jersey Experiment Station. They found that calves raised according to this system did not make as much growth during the first 180 days of life as calves fed liberally on whole milk and skim milk. They also reported that such calves were especially subject to digestive troubles and a cough during the first six months of life or while they were fed the dry grain mixture. However, they stated that the digestive troubles were minimized when the calves were allowed a free access to water. They also stated that the calves appeared shabby and under nourished during the early months of dry grain feeding. However, after the calves were six months of age they rapdily recovered in appearance and size and were about normal by one year of age. The gains made after they were six months of age were made at a greater rate per unit intake of feed.

From the review of literature it is evident that more investigation is needed to determine the best system of raising dairy calves on a minimum amount of whole milk.

# EXPERIMENTAL WORK

## OBJECT

Whole milk is usually too expensive in whole milk areas to be used for raising dairy calves. Consequently, dairymen in these areas frequently do not raise their best heifer calves for replacement in their dairy herds.

However, to improve the herd and keep it free from disease it is desirable for dairymen to raise calves from their best cows.

The object of this experiment is to determine a more satisfactory system of raising calves in areas where whole milk is sold. Two systems of raising calves with a minimum of whole milk will be compared with the system of feeding calves in the college dairy herd where liberal amounts of milk are fed. The system of raising calves on a minimum amount of milk recommended by the New Jersey Experiment Station which has been widely advocated and a similar system in which skim milk powder is supplemented with grains will be used in this investigation.

# PLAN

Three lots of calves, with five in each lot will be used. The calves will be placed on experiment as near after birth as possible and continued to first freshening time. The calves in each lot will be placed on experiment so as to make the lots as even as possible in respect to health, size and strength of the separate individuals.

Lot I. 5 calves. This lot will be raised on the present system of raising calves at the M. S. C. dairy barn.

Lot I or the Check Lot.

1. Leave the calf with the dam for 12 hours.
2. Feed ( hand) whole milk. (9% of body weight)
3. (a) Mother's milk 7 days ( 3 feeds per day)
   (b) Whole milk to 30 days of age.
4. Feed skim milk after 30 days of age to six months of age.
   (a) Up to 16 pounds for Guernseys and Jerseys.
   (b) Up to 20 pounds for Holsteins and Ayrshires.
5. Whole corn and oats up to 60 days of age.
   Grain mixture after 60 days of age, all calf will clean up to six pounds daily.
   100 pounds ground corn, 100 pounds ground oats, 100 pounds wheat bran, 100 pounds linseed oil meal, one percent bone meal, and one percent salt.
6. Good quality alfalfa hay all calf will clean up.

Lot II. 5 calves. This lot will be raised on the New Jersey System of raising calves.

New Jersey System:

1. Leave calf with dam for two days.
2. Feed (hand) a maximum of three quarts of whole milk, three feeds per day for ten days. Then twice daily for thirty days.
3. Place the grain mixture in the feed box after the first week. Grain mixture: 100 pounds yellow corn meal, 150 pounds ground oats, 50 pounds wheat bran, 50 pounds linseed oil meal, 50 pounds soluble blood flour, 4 pounds finely pulverized steamed bone meal, 4 pounds finely pulverized limestone, 4 pounds salt.
4. Place good alfalfa, clover, or mixed hay before the calf after the first week.
5. At end of third week the milk should be diluted with water so that by the end of the thirtieth day they will get the grain mixture, legume hay, and water.
6. By the thirtieth day one pound of dry grain mixture and plenty of hay placed before the calf in the morning should be enough to take care of the calf for 24 hours. Free access to water at all times. After the calf is six months old gradually replace the first dry grain mixture with the following grain mixture:

   100 pounds yellow corn, 100 pounds ground oats, 100 pounds wheat bran, 30 pounds linseed oil meal, and feed six to eight pounds daily with all the alfalfa hay they will eat.

Lot III or the M. S. C. Lot. 5 calves. Experimental Method.

Lot III will be raised the same as Lot II except -

1. Whole milk up to 45 days of age.
2. The following grain mixture will be used up to six months of age:

   100 pounds of corn, 100 pounds wheat middlings, 150 pounds skim milk powder, one percent salt, one percent bone meal.
3. After six months of age, grain mixture up to four to five pounds daily.

   200 pounds corn, 100 pounds oats, 100 pounds cottonseed meal, one percent salt, one percent bone meal.

Silage will be introduced into rations of all lots after six months of age. After six months of age calves will be allowed to run on pasture during pasture season. In all lots the judgment of the feeder will be exercised in changing the animals from one ration to another. The times set for changing feeds should be followed as closely as possible but not to the extent of sacrificing the animal in question. The feeder will be guided by the health and strength of the individual and the feces which they pass. In case the feces become odorous and watery the judgment of the feeder whould be exercised as to the rate of changing the ration.

Management

Water. All animals in Lots II and III up to six months of age will have free access to water at all times.

Shelter. All animals will be kept in the new dairy barn. Individual calf pens will be used while the calves are small. After the calves are five to six months old they will be placed in pens.

Bedding. Wood shavings will be used throughout the experiment for bedding.

Care. The animals will be cared for by the calf herdsman.

Calculation of Rations. The nutrients consumed will be kept as close as possible to the Armsby Standard especially the protein intake. Rations will be calculated each month. The body weight to be used in calculating requirements for the ensuing month will be that obtained the first of the month plus 20 pounds.

Collection of Data

Health. Notes will be taken daily by the calf herdsman in charge if any abnormalities appear. Special care will be taken to note the occurrence of scours, pneumonia, and lice.

Weight. All animals will be weighed every 10 days up to six months of age and for three consecutive days every thirty-day period during the experiment. Heifers freshening will be weighed immediately after calving.

Growth. All animals will be measured every thirty-days for body development.

Reproduction. An accurate record of all breeding data will be kept including occurrence of all estral periods. The health and strength of all calves dropped will be noted. Birth weights and gestation periods will also be noted.

Feed Consumed. An accurate record of all feed consumed by each individual will be kept. In case where several animals are kept in a pen the hay will be weighed for all the animals and the amount consumed by each individual calculated.

<u>Photographs.</u> Photographs of the calves to be placed on experiment will be taken as soon after birth as possible, at six months of age, and at first calving time.

## EXPERIMENTAL PROCEDURE

The animals used in this experiment were purebred calves from the college herd. They were divided into three lots of five calves each. One Ayshire, two Guernsyes, four Jerseys and eight Holsteins were used. The summary of this information is given in Table A.

Management.

Shelter. All animals were kept in the new dairy barn in individual pens until they were five months of age when they were grouped according to lotsand placed in larger pens. After about eight months of age they were placed in stanchions.

Bedding. As planned.

Care. As planned.

Water. The calves in Lots II and III were watered twice daily at first, but later, as the water consumption increased, they were watered three times daily until they were placed in pens according to lots. Thereafter they had free access to water at all times. The animals of Lot I were offered water after they were fed skim milk which was twice daily.

Calculation of Rations. It was not necessary to calculate the rations in advance as called for in the plan. The calves were fed all the grain they would eat up to the maximum amount called for by the system. They were also allowed all of the good quality alfalfa hay they would eat.

Collection of Data

Growth

Weight. As planned.

Height at Withers. As planned.

Health. As planned.

Feed Consumed. As planned.

Appearance of the Animals. Condition of hair coat and the amount of flesh carried.

Breeding Dates and Estral Cycles. As planned.

Photographs. A photograph was taken of each animal as soon as possible after birth, at 180 days of age, and at the close of the experiment.

Feeds and Methods of Feeding. As planned.

## EXPERIMENTAL RESULTS

### Growth

Weight. This experiment took into consideration mainly health andgrowth of the animals from birth to one year of age. Table A shows the birth weight and height for each of the three lots of calves. Table No. XXXIII is a summary of the growth in weight made by the animals from birth to 360 days of age. These tables and charts 1 to 15 show that at 180 days of age animals in the check group gained 273.6 pounds, those on the New Jersey system gained 207 pounds as compared to 213.8 pounds gain for the animals on the M. S. C. system.

From 180 to 360 days of age these animals in the check lot gained an average of 242.8 pounds. The New Jersey group gained 270.3 pounds and the animals in the M. S. C. group gained 263.3 pounds.

The total gain from birth to 360 days of age amounted to 516.4 pounds for Lot I, 447.3 pounds for Lot II and 477.1 pounds for Lot III.

Height at Withers. Charts 1 to 5 show that from birth to 180 days of age the animals in the check lot gained on an average 31.2 cms., the New Jersey group 24.03 cms., and the M. S. C. group 26.1 cms. in height at withers.

From 180 to 360 days of age the check lot or Lot I, gained 14 cms., the M. S. C. group or Lot III 15.2 cms. in height at withers.

The total gains in height at withers from birth to 360 days of age was 45.2 cms. for the check lot, 41.6 cms. for Lot II or the New Jersey group and 41.3 cms. for Lot III or the M. S. C. Group.

Health of Animals

During the first 180 day period the calves in Lot I were decidedly healthier than the calves which were fed by the M. S. C. system or the New Jersey system. This was especially true in case of digestive disturbances which were particularly noticeable among the calves fed according to the M. S. C. and New Jersey systems at the time they were weaned to the dry grain mixture.

The calves raised according to the New Jersey and M. S. C. systems were subject to a "dry cough" while those raised by the check system were unaffected.

The cough was followed by pneumonia in case of animals No. 24 and 162 raised on the M. S. C. system and animal No. 163 on the New Jersey system. Two of the three animals, No. 162 and 163, died as a result of pneumonia.

Most of the calves used in this investigation, regardless of the ration fed, were affected by a swelling of the jaws. This condition also occured among the calves in the M. S. C. calf herd during the same period that it appeared among the experimental calves. It was impossible to determine the cause of this condition. The calves usually manifested scours for two or three days following the disappearance of the swelling. During the second 180 day period there was no difference in the health of the rwo lots.

Appearance of the Animals

After the calves on the New Jersey and M. S. C. systems were weaned to the dry grain mixtures there was a period of about 90 days when the animals had a rough coat of hair, carried less flesh, and made less growth than animals in Lot I fed skim milk. However, at about 150 days of age these calves also became smooth in the hair coat, took on more flesh, and grew at a faster rate so that by 360 days of age there was no apparent difference between the animals of the three lots in these respects.

Animal No. 131 of the check lot became masculine in appearance or became coarse about the neck and withers and developed a high tail head and a coarse coat of hair.

Estral Periods

Three of the animals on the experiment, No. 24 of Lot III and 131 and 181 of Lot I, had estral periods previous to one year of age. Animal 131 of Lot I developed cystic ovaries following the first estral period.

Feed Consumption

During the first half of the experiment there was considerable difference in thefeed intake between the three lots of calves.

The individual feed records are shown in Tables I to XXX, inclusive. Table XXXI is a summary of the individual feed records. It shows that the calves in check lot consumed 229.9 pounds of whole milk, 2,155.9 pounds of skim milk, 335 pounds of grain, and 455.4 pounds of hay.

Considerable difficulty was encountered in getting the calves of the M. S. C. lot to eat their grain mixture. This was due to the fineness of the mixture and the stickiness of the skim milk powder when wet.

The calves in the New Jersey Lot consumed 149 pounds of whole milk, 438.7 pounds of grain and 547.8 pounds of hay.

Lot III or the M. S. C. group consumed 272.3 pounds of whole milk, 404.4 pounds of grain and 533.8 pounds of hay.

**Water**

While the calves were young they were watered twice daily. They were watered three times daily from about 80 to 90 days of age after which they were grouped according to lots and placed in larger pens where they had free acces to water.

**Photographs**

Photographs were taken as soon after birth as possible, at 180 days of age, and as near as possible to the time of reporting the results. The pictures, therefore, do not show the shaggy appearance and emaciated condition of the animals which were mentioned under Appearance of Animals. Plates 1 to 5 show the calves of the check Lot as they appeared at birth, plates 16 to 20 as they appeared at 180 days and 29 to 33 as they appeared at the end of the experiment.

The appearance of the calves in the New Jersey Lot, at birth, is shown in plates 6 to 10, at 180 days in plates 21 to 24 and at the end of the experiment in plates 34 to 36.

The calves in the M. S. C. Lot appeared at birth, as they are shown in plates 11 to 15, at 180 days plates 25 to 28, and at the end of the experiment, plates 37 to 40.

## DISCUSSION OF EXPERIMENTAL RESULTS

### Growth

The calves in Lot I which received whole milk until thirty days of age and skim milk to 180 days of age supplemented with a grain mixture containing equal parts of whole corn, whole oats, linseed oil meal, and wheat bran, made an average daily gain of 1.52 pounds during the first 180 day period, and 1.35 pounds per day during the second 180 day period. While the calves fed according to the New Jersey system which received whole milk for thirty days, then weaned to a dry grain mixture made an average daily gain of 1.15 pounds during the first 180 day period, and 1.50 pounds per day during the second 180 day period. The calves fed according to the M. S. C. system, which received whole milk to forty-five days of age and at that time weaned to a dry grain mixture averaged 1.19 pounds per day for the first 180 day period, and 1.46 pounds during the second 180 day period.

During the first 180 day period the calves in the Check Lot gained on an average of 67 pounds more per animal than the animals of the New Jersey system and 60 pounds more than those of the M. S. C. system.

The slower rate of gain made by the calves fed according to the New Jersey and M. S. C. system was probably due to the lack of feed intake after changing the calves from milk to the dry grain mixtures. For a period of tem days to two weeks following this change they did not readily eat the grain mixtures.

During the second 180 day period, although they were fed liberally, the animals in Lot I gained less than during the first period. This indicated that a greater percentage of the growth impulse was used during the first period consequently there was less remaining to be used during the second period.

The feed consumption of the calves in the three lots was approximately equal during the second period as shown in Table XXXIII. However, during this period the animals on the New Jersey system gained 27 pounds each and those of the M. S. C. Lot gained 20 pounds more per calf than those of the check lot. Thegreater growth of the calves fed according to the New Jersey and M. S. C. systems during the second 180 day period may have been due to the presence of a greater percentage of growth impulse. The results of Osborne, Thompkins, Waters, and Eckles showed that animals stunted during the growing period have the ability to reach normal size if fed liberally before the growth impulse has died.

The results showthat during the second period the animals raised according to the New Jersey and M. S. C. systems made a greater gain per unit intake of feed than the animals in Lot I. Thompson and co-workers and Osborne and Mendel found that following a period of suppressed growth rats made greater gains per unit of food intake.

<u>Height at Withers</u>. The calves in Lot I gained 29.7 cms. in height at withers from birth to 180 days of age. During the same time the calves raised according to the New Jersey system gained 24 cms. and the calves in Lot III gained 26.11 cms. These

figures show that the gains in height at withers of Lot I surpassed those made by Lots II and III.

At 360 days of age the calves in Lot I were approximately 113.4 cms. at height at withers, Lot II was 112.3 cms., and Lot III was 112.4 cms. in height. This represents a gain of 14 cms., 17.6 cms., and 15.2 cms., respectively, for the animals in Lots I, II and III for the second 180 day period.

The results from the standpoint of growth as measured in body weight and height at withers indicate that growth impulse is not easily destroyed but tends to persist for a relatively long period of time.

Feed Consumption

There was considerable difference in the feed intake of the three lots of calves during the first period as shown in Table XXXIII. During the first period Lot I consumed on an average of about 2,200 pounds of skim milk, 230 pounds of whole milk, 335 pounds of grain and 456 pounds of hay. In comparing the feed consumed by the calves in Lot II with that consumed by those of Lot I it was found that Lot II consumed about 100 pounds less whole milk but 100 pounds more grain and 90 pounds more hay than the animals in Lot I.

When the animals in Lot II were 30 to 40 days of age and those of Lot III were 45 days of age they did not consume enough total digestible nutrients, according to the Morrison Standard, to maintain body weight as shown in TablesVI to XIV. Considerable difficulty was encountered in getting the calves of Lots II and III to eat the grain mixture immediately after weaning from whole milk. This was especially pronounced among the calves in Lot III. Both grain mixtures were fine in texture. The grain mixture fed to the calves in Lot III was the finest and would become sticky and pasty upon eating. This was due to the presence of skim milk powder in the mixture and also due to the fineness of the mixture. These two factors may have been responsible for the small feed consumption.

During the second 180 day period there was approximately no difference in the total amount of feed consumed by the three lots of animals as shown in Table XXXIII.

Health and Appearance of the Animals

During the first 180 days of the experiment the calves in Lot I were decidedly healthier than the calves in either of the other two lots. The calves in Lots II and III were subject to scours and had a chronic "dry cough". This was probably due to the fineness of the grain mixture since it was more pronounced among the calves in Lot III that received the more finely ground grain mixture. It was present to a less extent in Lot II where a slightly coarser mixture was fed and was entirely absent from Lot I where whole grains were fed.

Investigators at the New Jersey Experiment Station reported similar results with calves fed the New Jersey Grain Mixture. They attributed this condition to the irritation caused by inhaling the fine particles of grain.

The cough was followed by pneumonia in case of animals No. 163 of Lot II and animals No. 24 and 162 of Lot III. Two

of these animals, No. 162 and 163 died as the result of pneumonia. However, the cause of pneumonia among these calves was not definitely known.

Following the weaning of the calves to the dry grain mixtures, the calves in Lots II and III had a rough coat of hair, carried less flesh, and made less growth than animals in Lot I. At about 130 to 150 days of age the calves in Lots II and III improved in the hair coat, and begun to grow at a faster rate, so that by 360 days of age there was very little difference between the animals of the threelots in these respects. During this early period the calves were especially subject to scours indicating that the feeds were probably responsible for this condition. Schalk and co-workers of the North Dakota Experiment Station reported that the digestive system of calves at 30 or even 50 days of age was not sufficiently developed to digest dry grain mixtures. They found that the temperature of the liquids fed was also an important factor in causing the "lips" of the esophageal groove to close. When dry feeds or cold liquids were fed the groove did not close and thus permitted the feed to enter the rumen where fermentation took place and caused digestive troubles.

These results are in accordance with many workers who also showed that young calves fed a dry grain mixture always pass through the same stages of appearance, delayed growth, and finally an accelerated rate of growth so that by one year of age or at most by the first calving date they are normal or above for the breed.

## Water Consumption

The animals did not have free access to water until they were about 150 days of age. This may have been responsible for the difficulty in getting the calves in Lots II and III to eat the dry grain mixtures. Bender of the New Jersey Experiment Station reported better results when calves fed the New Jersey dry grain mixture had free access to water at all times.

## SUMMARY

1. The calves weaned from whole milk to a dry grain mixture at an early age were especially subject to scours.

2. The fineness of the dry grain mixture may be responsible for the "dry cough" prevalent among calves fed such a ration.

3. The animals in the Check Lot made greater gains and were healthier throughout the experiment than the animals in either of the other two lots. This was especially noticeable during the first 180 day period.

4. The calves in the New Jersey and M. S. C. Lots were stunted during the first 180 day period but they recovered and showed a greater rate of growth during the second 180 day period than the calves in the Check Lot. However, at 360 days of age the animals in the Check Lot were but slightly superior in size to those in the other two Lots. The New Jersey and M. S. C. Lots were unable to overcome the lead gained by the Check Lot during the first 180 days.

5. There was approximately no difference in the size of the animals raised according to the New Jersey and M. S. C. systems.

6. The animals raised according to the New Jersey system were healthier than those raised by the M. S. C. system.

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# APPENDIX

TABLE A showing animals used in this experiment.

Lot I

| Animal No. | Breed | Date of Birth | Birth Weight | Normal Weight | Above Below Normal | Birth Height Withers | Normal Height | Above Below Normal |
|---|---|---|---|---|---|---|---|---|
| | | | Lbs. | Lbs. | Lbs. | Cms. | Cms. | Cms. |
| 87 | Jersey | 12-4-29 | 55 | 55 | 0 | 69.0 | 66.1 | 2.9 |
| 88 | Jersey | 12-27-29 | 54 | 55 | -1 | 67.0 | 66.1 | .9 |
| 151 | Ayrshire | 11-22-29 | 73 | 69 | 4 | 73.0 | | |
| 160 | Holstein | 1-4-30 | 90 | 90 | 0 | 74.5 | 71.8 | 2.7 |
| 181 | Holstein | 4-10-30 | 86 | 90 | -4 | 74.0 | 71.8 | 2.2 |
| Total | | | 358 | | | 357.5 | | |
| Average per animal | | | 71.6 | | | 71.5 | | |

Lot II

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9's Du | Guernsey | 12-7-29 | 71 | | | 69.7 | | |
| 90 | Jersey | 4-1-30 | 56 | 55 | 1 | 67.0 | 66.1 | 0.9 |
| 165* | Holstein | 3-4-30 | 90 | 90 | 0 | 73.0 | 71.8 | 1.2 |
| 164 | Holstein | 3-4-30 | 100 | 90 | 10 | 75.0 | 71.8 | 3.2 |
| 166 | Holstein | 4-2-30 | 88 | 90 | -2 | 74.3 | 71.8 | 2.5 |
| Total | | | 405 | | | 359.0 | | |
| Average per animal | | | 81 | | | 71.8 | | |

* Died during experiment.

Lot III

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 24 | Guernsey | 4-7-30 | 65 | | | 70.0 | | |
| 89 | Jersey | 1-24-30 | 52 | 55 | -3 | 66.0 | 66.1 | -.1 |
| 159 | Holstein | 12-25-29 | 99 | 90 | 9 | 76.0 | 71.8 | 4.2 |
| 161 | Holstein | 2-3-30 | 84 | 90 | -6 | 73.0 | 71.8 | 1.2 |
| 162* | Holstein | 2-27-30 | 86 | 90 | -4 | 71.3 | 71.8 | -.5 |
| Total | | | 386 | | | 356.3 | | |
| Average per animal | | | 77.2 | | | 71.3 | | |

* Died during experiment.

TABLE I  Animal No. 87 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed: Whole Milk | Feed Consumed: Skim Milk | Feed Consumed: Grain | Hay | Nutrients Required: Digestible Protein. | Nutrients Required: T. D. N. | Nutrients Consumed: Digestible Protein. | Nutrients Consumed: T. D. N. |
|---|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 55 | | | | | 0.18 | 1.05 | | |
| 16 | 56 | 64.5 | | | | 0.18 | 1.06 | 0.13 | 0.65 |
| 26 | 58 | 53.0 | | 1.4 | 0.6 | 0.19 | 1.10 | 0.19 | 0.99 |
| 36 | 68 | 60.0 | 3.0 | 3.0 | 2.2 | 0.22 | 1.29 | 0.26 | 1.34 |
| 46 | 82 | 7.4 | 67.1 | 3.6 | 3.4 | 0.26 | 1.57 | 0.33 | 1.18 |
| 56 | 84 | | 92.0 | 5.1 | 5.0 | 0.27 | 1.60 | 0.43 | 1.48 |
| 66 | 96 | | 94.0 | 4.3 | 3.4 | 0.31 | 1.82 | 0.41 | 1.36 |
| 76 | 106 | | 90.0 | 11.0 | 11.0 | 0.34 | 2.01 | 0.53 | 2.22 |
| 86 | 115 | | 90.0 | 13.6 | 12.1 | 0.37 | 2.19 | 0.57 | 2.79 |
| 96 | 121 | | 99.0 | 19.0 | 11.0 | 0.39 | 2.30 | 0.63 | 2.91 |
| 106 | 153 | | 110.0 | 23.1 | 22.3 | 0.44 | 2.83 | 0.83 | 3.91 |
| 116 | 168 | | 134.0 | 25.0 | 25.0 | 0.49 | 3.11 | 0.96 | 4.41 |
| 126 | 188 | | 146.5 | 25.5 | 29.0 | 0.55 | 3.48 | 1.05 | 4.77 |
| 136 | 201 | | 150.0 | 25.0 | 29.0 | 0.58 | 3.72 | 1.06 | 4.76 |
| 146 | 217 | | 150.0 | 25.0 | 30.0 | 0.63 | 4.01 | 1.07 | 4.81 |
| 156 | 233 | | 159.0 | 29.0 | 38.0 | 0.68 | 4.31 | 1.22 | 5.61 |
| 166 | 246 | | 160.0 | 21.5 | 32.0 | 0.71 | 4.55 | 1.10 | 4.74 |
| 176 | 271 | | 160.0 | 20.0 | 31.0 | 0.70 | 4.74 | 1.07 | 4.58 |
| 180 | 277 | | 64.0 | 8.0 | 12.0 | 0.72 | 4.85 | 1.06 | 4.52 |
| Total | | 184.9 | 1,768.6 | 263.1 | 297.0 | | | | |

TABLE II Animal No. 88 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Whole Milk | Feed Consumed Skim Milk | Grain | Hay | Nutrients Required Digestible Protein. | T. D. N. | Nutrients Consumed Digestible Protein. | T. D. N. |
|---|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 5 | 54 | 11.0 | | | | 0.17 | 1.02 | 0.12 | 0.59 |
| 15 | 58 | 60.6 | | 0.6 | 0.1 | 0.19 | 1.10 | 0.21 | 1.08 |
| 25 | 68 | 69.6 | | 3.8 | 2.7 | 0.22 | 1.29 | 0.29 | 1.56 |
| 35 | 75 | 44.7 | 28.8 | 5.5 | 5.0 | 0.24 | 1.45 | 0.35 | 1.66 |
| 45 | 86 | | 80.0 | 7.6 | 6.0 | 0.28 | 1.65 | 0.41 | 1.61 |
| 55 | 94 | | 80.0 | 9.0 | 9.6 | 0.30 | 1.79 | 0.47 | 1.91 |
| 65 | 104 | | 84.9 | 10.6 | 10.4 | 0.33 | 1.98 | 0.50 | 2.11 |
| 75 | 116 | | 100.0 | 11.0 | 19.4 | 0.37 | 2.20 | 0.66 | 2.75 |
| 85 | 135 | | 100.0 | 20.0 | 20.0 | 0.45 | 2.53 | 0.74 | 3.46 |
| 95 | 148 | | 134.0 | 22.5 | 24.0 | 0.47 | 2.81 | 0.92 | 4.15 |
| 105 | 165 | | 146.5 | 25.0 | 29.0 | 0.48 | 3.05 | 1.04 | 4.75 |
| 115 | 182 | | 150.0 | 25.0 | 29.0 | 0.55 | 3.37 | 1.06 | 4.76 |
| 125 | 199 | | 150.0 | 25.0 | 30.0 | 0.58 | 3.68 | 1.07 | 4.81 |
| 135 | 214 | | 159.0 | 29.0 | 38.0 | 0.62 | 3.96 | 1.27 | 5.61 |
| 145 | 229 | | 160.0 | 21.5 | 32.0 | 0.66 | 4.24 | 1.10 | 4.74 |
| 155 | 255 | | 160.0 | 20.0 | 31.0 | 0.66 | 4.46 | 1.07 | 4.58 |
| 165 | 275 | | 160.0 | 20.0 | 30.0 | 0.71 | 4.78 | 1.06 | 4.55 |
| 175 | 290 | | 160.0 | 20.0 | 30.0 | 0.75 | 5.08 | 1.06 | 4.53 |
| 180 | 307 | | 092.4 | 17.9 | 25.2 | 0.80 | 5.37 | 1.07 | 4.99 |
| Total | | 185.9 | 1,945.6 | 293.8 | 371.4 | | | | |

TABLE III Animal No. 160 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed: Whole Milk | Feed Consumed: Skim Milk | Feed Consumed: Grain | Feed Consumed: Hay | Nutrients Required: Digestible Protein. | Nutrients Required: T. D. N. | Nutrients Consumed: Digestible Protein. | Nutrients Consumed: T. D. N. |
|---|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 90 | | | | | 0.29 | 1.71 | | |
| 5 | 92 | 32.5 | | | | 0.29 | 1.75 | 0.21 | 1.05 |
| 15 | 97 | 72.0 | | 1.8 | 0.6 | 0.31 | 1.84 | 0.26 | 1.33 |
| 25 | 107 | 87.6 | | 4.5 | 3.0 | 0.34 | 2.03 | 0.36 | 1.92 |
| 35 | 122 | 49.0 | 44.0 | 5.0 | 4.2 | 0.39 | 2.32 | 0.41 | 1.79 |
| 45 | 134 | | 94.0 | 6.9 | 8.9 | 0.43 | 2.55 | 0.49 | 1.84 |
| 55 | 143 | | 102.5 | 8.3 | 10.8 | 0.46 | 2.72 | 0.55 | 2.12 |
| 65 | 154 | | 120.0 | 16.4 | 19.4 | 0.45 | 2.85 | 0.78 | 3.34 |
| 75 | 185 | | 138.0 | 24.3 | 28.5 | 0.54 | 3.42 | 1.00 | 4.56 |
| 85 | 203 | | 154.0 | 29.0 | 31.5 | 0.59 | 3.76 | 1.13 | 5.23 |
| 95 | 232 | | 165.5 | 30.0 | 35.5 | 0.67 | 4.29 | 1.22 | 5.62 |
| 105 | 247 | | 170.0 | 30.0 | 39.0 | 0.72 | 4.57 | 1.28 | 5.84 |
| 115 | 271 | | 179.5 | 32.0 | 41.5 | 0.70 | 4.74 | 1.35 | 6.21 |
| 125 | 288 | | 180.0 | 39.0 | 47.5 | 0.75 | 5.04 | 1.48 | 7.05 |
| 135 | 311 | | 180.0 | 31.5 | 44.0 | 0.81 | 5.44 | 1.38 | 6.30 |
| 145 | 335 | | 180.0 | 30.0 | 43.5 | 0.87 | 5.86 | 1.36 | 6.16 |
| 155 | 356 | | 183.0 | 30.0 | 40.0 | 0.82 | 5.87 | 1.35 | 6.01 |
| 165 | 376 | | 199.0 | 30.0 | 40.0 | 0.86 | 6.20 | 1.39 | 6.16 |
| 175 | 396 | | 194.0 | 30.0 | 40.0 | 0.91 | 6.53 | 1.37 | 6.11 |
| 180 | 406 | | 30.0 | 16.0 | 31.0 | 0.93 | 6.70 | 1.14 | 6.18 |
| Total | | 241.1 | 2,313.5 | 394.7 | 508.7 | | | | |

TABLE IV    Animal No. 181 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Whole Milk | Feed Consumed Skim Milk | Feed Consumed Grain | Hay | Nutrients Required Digestible Protein. | Nutrients Required T. D. N. | Nutrients Consumed Digestible Protein. | Nutrients Consumed T. D. N. |
|---|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 86 | | | | | 0.28 | 1.65 | | |
| 9 | 91 | 61.5 | | | | 0.29 | 1.75 | 0.23 | 1.11 |
| 19 | 95 | 77.1 | | 0.8 | 0.7 | 0.30 | 1.81 | 0.27 | 1.35 |
| 29 | 102 | 84.0 | | 1.4 | 1.9 | 0.33 | 1.94 | 0.31 | 1.57 |
| 39 | 117 | 42.6 | 58.0 | 5.0 | 6.5 | 0.37 | 2.22 | 0.46 | 1.94 |
| 49 | 136 | | 130.0 | 10.0 | 10.9 | 0.44 | 2.58 | 0.67 | 2.50 |
| 59 | 149 | | 151.0 | 11.8 | 18.1 | 0.48 | 2.83 | 0.83 | 3.20 |
| 69 | 169 | | 160.0 | 16.4 | 20.0 | 0.49 | 3.13 | 0.93 | 3.74 |
| 79 | 195 | | 160.0 | 23.5 | 21.5 | 0.57 | 3.61 | 1.00 | 4.36 |
| 89 | 215 | | 160.0 | 24.5 | 30.0 | 0.62 | 3.98 | 1.10 | 4.87 |
| 99 | 229 | | 167.0 | 27.0 | 33.5 | 0.66 | 4.24 | 1.18 | 5.30 |
| 109 | 247 | | 170.0 | 28.0 | 35.0 | 0.72 | 4.57 | 1.22 | 5.49 |
| 119 | 273 | | 174.0 | 31.0 | 43.5 | 0.71 | 4.78 | 1.35 | 6.18 |
| 129 | 295 | | 180.0 | 35.0 | 50.0 | 0.77 | 5.16 | 1.47 | 6.88 |
| 139 | 309 | | 180.0 | 39.5 | 50.0 | 0.80 | 5.41 | 1.51 | 7.22 |
| 149 | 323 | | 180.0 | 40.0 | 56.0 | 0.84 | 5.65 | 1.58 | 7.57 |
| 159 | 341 | | 200.0 | 40.0 | 60.0 | 0.89 | 5.97 | 1.69 | 7.96 |
| 169 | 363 | | 200.0 | 40.0 | 60.0 | 0.83 | 5.99 | 1.69 | 7.96 |
| 180 | 378 | | 172.0 | 44.0 | 80.0 | 0.87 | 6.24 | 1.67 | 8.23 |
| Total | | 265.2 | 2,442.0 | 417.9 | 577.6 | | | | |

TABLE V  Animal No. 131 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed Whole Milk | Skim Milk | Grain | Hay | Nutrients Required Digestible Protein. | T. D. N | Nutrients Consumed Digestible Protein. | T. D. N. |
|---|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 73 | | | | | 0.23 | 1.39 | | |
| 18 | 75 | 97 | | | | 0.23 | 1.39 | 0.18 | 0.87 |
| 28 | 84 | 73.1 | | 0.1 | | 0.27 | 1.60 | 0.31 | 1.44 |
| 38 | 94 | 84.5 | 2.0 | 2.2 | | 0.30 | 1.79 | 0.30 | 1.55 |
| 48 | 107 | 18.0 | 93.0 | 2.3 | 6.2 | 0.34 | 2.03 | 0.48 | 1.63 |
| 58 | 125 | | 135.0 | 3.7 | 20.0 | 0.40 | 2.38 | 0.73 | 2.54 |
| 68 | 139 | | 150.0 | 3.5 | 27.5 | 0.44 | 2.64 | 0.86 | 3.05 |
| 78 | 156 | | 150.0 | 3.4 | 22.0 | 0.45 | 2.89 | 0.80 | 2.76 |
| 88 | 168 | | 142.5 | 5.2 | 22.5 | 0.49 | 3.11 | 0.79 | 2.86 |
| 98 | 187 | | 138.0 | 8.7 | 25.0 | 0.54 | 3.46 | 0.84 | 3.21 |
| 108 | 197 | | 160.0 | 21.6 | 40.3 | 0.57 | 3.64 | 1.18 | 5.18 |
| 118 | 233 | | 173.5 | 29.3 | 50.0 | 0.68 | 4.31 | 1.40 | 6.39 |
| 128 | 255 | | 180.0 | 30.9 | 50.0 | 0.66 | 4.46 | 1.44 | 6.57 |
| 138 | 286 | | 185.5 | 37.9 | 49.5 | 0.74 | 5.01 | 1.51 | 7.12 |
| 148 | 298 | | 190.0 | 40.0 | 48.5 | 0.77 | 5.22 | 1.53 | 7.27 |
| 158 | 320 | | 187.5 | 40.0 | 50.0 | 0.83 | 5.60 | 1.54 | 7.33 |
| 168 | 330 | | 200.0 | 39.5 | 57.0 | 0.86 | 5.78 | 1.66 | 7.77 |
| 178 | 356 | | 193.0 | 31.0 | 46.4 | 0.82 | 5.87 | 1.45 | 6.51 |
| 180 | 358 | | 30.0 | 6.5 | 9.5 | 0.82 | 5.91 | 0.18 | 0.51 |
| Total | | 272.5 | 2,310.0 | 305.8 | 524.4 | | | | |

TABLE VI Animal No. 90 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed: Whole Milk | Feed Consumed: Grain | Feed Consumed: Hay | Nutrients Required: Digestible Protein | Nutrients Required: T. D. N | Nutrients Consumed: Digestible Protein | Nutrients Consumed: T. D. N. |
|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 56 | | | | 0.18 | 1.06 | | |
| 8 | 56 | 38.0 | 0.1 | | 0.18 | 1.06 | 0.16 | 0.79 |
| 18 | 62 | 60.0 | 1.7 | 1.0 | 0.20 | 1.18 | 0.24 | 1.62 |
| 28 | 66 | 41.0 | 2.9 | 2.7 | 0.21 | 1.25 | 0.23 | 1.02 |
| 38 | 68 | 1.0 | 5.2 | 6.4 | 0.22 | 1.29 | 0.17 | 0.73 |
| 48 | 76 | | 7.8 | 12.4 | 0.24 | 1.44 | 0.28 | 1.22 |
| 58 | 82 | | 11.4 | 16.0 | 0.26 | 1.56 | 0.39 | 1.67 |
| 68 | 93 | | 14.1 | 18.8 | 0.30 | 1.77 | 0.47 | 2.01 |
| 78 | 94 | | 16.0 | 20.0 | 0.30 | 1.79 | 0.52 | 2.21 |
| 88 | 103 | | 17.6 | 21.0 | 0.33 | 1.96 | 0.56 | 2.38 |
| 98 | 115 | | 23.0 | 29.0 | 0.37 | 2.19 | 0.76 | 3.20 |
| 108 | 124 | | 25.0 | 30.0 | 0.40 | 2.36 | 0.81 | 3.40 |
| 118 | 131 | | 21.5 | 22.7 | 0.42 | 2.49 | 0.66 | 2.76 |
| 128 | 146 | | 22.5 | 30.0 | 0.47 | 2.77 | 0.76 | 3.20 |
| 138 | 155 | | 28.2 | 36.0 | 0.45 | 2.87 | 0.93 | 3.95 |
| 148 | 174 | | 30.0 | 50.0 | 0.50 | 3.22 | 1.11 | 4.80 |
| 158 | 181 | | 33.0 | 50.0 | 0.52 | 3.35 | 1.17 | 5.02 |
| 168 | 191 | | 35.0 | 50.0 | 0.55 | 3.53 | 1.21 | 5.17 |
| 178 | 207 | | 35.0 | 53.0 | 0.60 | 3.83 | 1.24 | 5.32 |
| 180 | 210 | | 7.0 | 11.0 | 0.61 | 3.89 | 1.30 | 5.45 |
| Total | | 140.0 | 337.0 | 460.0 | | | | |

TABLE VII Animal No. 164 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed: Whole Milk | Feed Consumed: Grain | Feed Consumed: Hay | Nutrients Required: Digestible Protein | Nutrients Required: T. D. N | Nutrients Consumed: Digestible Protein | Nutrients Consumed: T. D. N. |
|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 100 | | | | 0.32 | 1.90 | | |
| 6 | 95 | 26.0 | | | 0.30 | 1.62 | 0.15 | 0.70 |
| 16 | 102 | 60.0 | 1.3 | 1.8 | 0.33 | 1.94 | 0.31 | 1.16 |
| 26 | 108 | 50.0 | 1.6 | 3.7 | 0.35 | 2.05 | 0.24 | 1.12 |
| 36 | 113 | 4.5 | 3.7 | 11.5 | 0.36 | 2.15 | 0.20 | 0.93 |
| 46 | 121 | | 5.2 | 15.3 | 0.39 | 2.30 | 0.26 | 1.17 |
| 56 | 129 | | 12.0 | 20.0 | 0.41 | 2.45 | 0.44 | 1.92 |
| 66 | 137 | | 15.4 | 23.4 | 0.44 | 2.60 | 0.55 | 2.35 |
| 76 | 153 | | 26.2 | 30.0 | 0.44 | 2.83 | 0.83 | 3.49 |
| 86 | 168 | | 29.8 | 34.5 | 0.49 | 3.11 | 0.95 | 3.99 |
| 96 | 190 | | 30.0 | 39.5 | 0.55 | 3.52 | 1.00 | 4.26 |
| 106 | 204 | | 32.5 | 43.5 | 0.59 | 3.77 | 1.09 | 4.65 |
| 116 | 217 | | 35.5 | 46.0 | 0.63 | 4.01 | 1.18 | 5.00 |
| 126 | 239 | | 40.0 | 50.0 | 0.69 | 4.42 | 1.31 | 5.54 |
| 136 | 258 | | 43.0 | 54.5 | 0.67 | 4.52 | 1.41 | 5.99 |
| 146 | 277 | | 45.0 | 58.5 | 0.72 | 4.85 | 1.49 | 6.35 |
| 156 | 300 | | 47.5 | 60.0 | 0.78 | 5.25 | 1.56 | 6.62 |
| 166 | 326 | | 50.0 | 60.0 | 0.85 | 5.71 | 1.61 | 6.80 |
| 176 | 323 | | 50.0 | 60.0 | 0.84 | 5.65 | 1.61 | 6.80 |
| 180 | 332 | | 20.0 | 24.0 | 0.86 | 5.81 | 1.60 | 6.80 |
| Total | | 140.5 | 488.7 | 636.2 | | | | |

TABLE VIII    Animal No. 166 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed Whole Milk | Feed Consumed Grain | Feed Consumed Hay | Nutrients Required Digestible Protein | Nutrients Required T. D. N | Nutrients Consumed Digestible Protein | Nutrients Consumed T. D. N. |
|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 88 | | | | 0.28 | 1.67 | | |
| 7 | 90 | 34.0 | | | 0.29 | 1.71 | 0.16 | 0.79 |
| 17 | 96 | 59.5 | 1.5 | 1.0 | 0.31 | 1.82 | 0.24 | 1.12 |
| 27 | 101 | 41.0 | 5.7 | 6.1 | 0.32 | 1.92 | 0.31 | 1.39 |
| 37 | 105 | 1.0 | 10.4 | 11.8 | 0.34 | 2.00 | 0.36 | 1.54 |
| 47 | 117 | | 13.8 | 17.8 | 0.37 | 2.22 | 0.46 | 1.94 |
| 57 | 126 | | 16.8 | 20.0 | 0.40 | 2.39 | 0.54 | 2.27 |
| 67 | 141 | | 21.7 | 23.4 | 0.45 | 2.68 | 0.67 | 2.81 |
| 77 | 150 | | 25.0 | 29.5 | 0.44 | 2.78 | 0.80 | 3.37 |
| 87 | 162 | | 26.0 | 30.0 | 0.47 | 3.00 | 0.82 | 3.47 |
| 97 | 180 | | 30.0 | 39.0 | 0.52 | 3.33 | 0.99 | 4.23 |
| 107 | 190 | | 33.5 | 40.0 | 0.55 | 3.52 | 1.07 | 4.54 |
| 117 | 208 | | 34.0 | 35.5 | 0.60 | 3.85 | 1.04 | 4.35 |
| 127 | 229 | | 36.5 | 43.5 | 0.66 | 4.24 | 1.17 | 4.94 |
| 137 | 240 | | 40.0 | 53.0 | 0.70 | 4.44 | 1.34 | 5.69 |
| 147 | 244 | | 40.0 | 60.0 | 0.71 | 4.51 | 1.41 | 6.06 |
| 157 | 258 | | 43.5 | 60.0 | 0.75 | 4.52 | 1.47 | 6.32 |
| 167 | 279 | | 42.0 | 50.0 | 0.81 | 4.88 | 1.34 | 5.69 |
| 177 | 296 | | 45.0 | 60.0 | 0.86 | 5.18 | 1.50 | 6.45 |
| 180 | 302 | | 13.5 | 18.0 | 0.88 | 5.29 | 1.50 | 6.43 |
| Total | | 135.5 | 478.9 | 598.6 | | | | |

TABLE IX  Animal No. 9's bull showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for per-iod | Av. body wt. | Feed Consumed: Whole Milk | Feed Consumed: Grain | Feed Consumed: Hay | Nutrients Required: Digestible Protein. | Nutrients Required: T. D. N | Nutrients Consumed: Digestible Protein. | Nutrients Consumed: T. D. N. |
|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 71 | | | | 0.25 | 1.35 | | |
| 15 | 75 | 72.5 | | | 0.24 | 1.45 | 0.18 | 0.90 |
| 25 | 75 | 60.5 | | | 0.24 | 1.45 | 0.20 | 0.98 |
| 35 | 81 | 45.0 | 2.0 | 0.3 | 0.26 | 1.54 | 0.18 | 0.85 |
| 45 | 88 | 4.0 | 8.7 | 3.2 | 0.28 | 1.67 | 0.21 | 0.87 |
| 55 | 92 | | 10.9 | 6.4 | 0.29 | 1.75 | 0.28 | 1.14 |
| 65 | 105 | | 14.3 | 18.9 | 0.33 | 1.96 | 0.48 | 2.04 |
| 75 | 112 | | 15.4 | 24.9 | 0.36 | 2.13 | 0.56 | 2.42 |
| 85 | 124 | | 17.3 | 25.0 | 0.40 | 2.36 | 0.61 | 2.57 |
| 95 | 128 | | 21.5 | 29.0 | 0.41 | 2.45 | 0.73 | 3.09 |
| 105 | 155 | | 29.5 | 38.0 | 0.45 | 2.87 | 0.97 | 4.14 |
| 115 | 168 | | 30.0 | 44.5 | 0.49 | 3.11 | 1.05 | 4.52 |
| 125 | 185 | | 35.0 | 40.5 | 0.54 | 3.42 | 1.11 | 4.68 |
| 135 | 204 | | 45.0 | 36.0 | 0.59 | 3.77 | 1.25 | 5.19 |
| 145 | 221 | | 39.3 | 40.0 | 0.64 | 4.09 | 1.18 | 4.25 |
| 155 | 257 | | 46.5 | 55.0 | 0.69 | 4.38 | 1.48 | 6.28 |
| 165 | 260 | | 50.0 | 50.0 | 0.68 | 4.55 | 1.50 | 6.28 |
| 175 | 280 | | 50.0 | 50.0 | 0.73 | 4.90 | 1.50 | 6.28 |
| 180 | 299 | | 35.0 | 35.0 | 0.78 | 5.23 | 1.50 | 6.28 |
| Total | | 180.0 | 450.4 | 496.7 | | | | |

TABLE X Animal No. 163 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed Whole Milk | Grain | Hay | Nutrients Required Digestible Protein | T. D. N | Nutrients Consumed Digestible Protein | T. D. N. |
|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 90 | | | | 0.32 | 1.90 | | |
| 7 | 85 | 44 | 0.6 | 0.4 | 0.27 | 1.62 | 0.12 | 0.6 |
| 17 | 89 | 60 | 1.8 | 2.5 | 0.28 | 1.69 | 0.27 | 1.23 |
| 27 | 100 | 29 | 4.0 | 6.0 | 0.32 | 1.90 | 0.24 | 1.08 |
| 37 | 104 | | 5.5 | 19.5 | 0.33 | 1.98 | 0.32 | 1.42 |
| 47 | 107 | | 10.7 | 20.0 | 0.34 | 2.03 | 0.42 | 1.82 |
| 57 | 117 | | 14.0 | 20.0 | 0.37 | 2.22 | 0.48 | 2.07 |
| 67 | 120 | | 13.8 | 21.5 | 0.38 | 2.28 | 0.50 | 2.13 |
| 77 | 128 | | 15.4 | 29.5 | 0.41 | 2.43 | 0.61 | 2.66 |
| 87 | 120 | 22 | 9.1 | 16.5 | 0.38 | 2.28 | 0.35 | 1.52 |
| 97 | 129 | 85 | 5.7 | 7.5 | 0.41 | 2.45 | 0.47 | 1.81 |
| 107 | | 85 | | | | | 0.28 | 1.38 |
| 117 | | 19 | | | | | 0.21 | 1.03 |
| Total | | 344 | 80.6 | 219.9 | | | | |

Died of pneumonia June 20, 1930.

TABLE XI Animal No. 24 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed: Whole Milk | Feed Consumed: Grain | Feed Consumed: Hay | Nutrients Required: Digestible Protein | Nutrients Required: T. D. N | Nutrients Consumed: Digestible Protein | Nutrients Consumed: T. D. N. |
|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 65 | | | | 0.21 | 1.24 | | |
| 2 | 70 | 2.0 | | | 0.22 | 1.33 | .03 | 0.16 |
| 12 | 70 | 60.0 | 2.0 | 0.5 | 0.22 | 1.33 | 0.25 | 1.17 |
| 22 | 70 | 52.0 | 1.2 | 0.7 | 0.22 | 1.33 | 0.21 | 0.98 |
| 32 | 72 | 60.0 | 4.7 | 3.5 | 0.23 | 1.37 | 0.34 | 1.54 |
| 42 | 86 | 47.0 | 7.3 | 6.6 | 0.28 | 1.63 | 0.38 | 1.71 |
| 52 | 95 | 9.0 | 12.0 | 10.6 | 0.30 | 1.81 | 0.39 | 1.70 |
| 62 | 108 | | 14.3 | 13.6 | 0.35 | 2.05 | 0.44 | 1.89 |
| 72 | 120 | | 17.4 | 16.0 | 0.38 | 2.28 | 0.54 | 2.27 |
| 82 | 133 | | 19.8 | 19.3 | 0.43 | 2.53 | 0.62 | 2.64 |
| 92 | 145 | 40.0 | 24.0 | 27.5 | 0.46 | 2.76 | 0.92 | 4.06 |
| 102 | 154 | 23.5 | 25.0 | 30.0 | 0.45 | 2.85 | 0.93 | 4.01 |
| 112 | 168 | 20.0 | 20.8 | 22.0 | 0.49 | 3.11 | 0.74 | 3.48 |
| 122 | 188 | | 23.3 | 30.0 | 0.55 | 3.48 | 0.81 | 4.33 |
| 132 | 207 | | 28.0 | 39.0 | 0.60 | 3.83 | 1.00 | 5.02 |
| 142 | 218 | | 30.0 | 49.0 | 0.63 | 4.03 | 1.15 | 5.90 |
| 152 | 237 | | 37.5 | 50.0 | 0.69 | 4.38 | 1.32 | 5.69 |
| 162 | 252 | | 40.0 | 50.0 | 0.66 | 4.41 | 1.37 | 5.90 |
| 172 | 258 | | 39.3 | 54.5 | 0.67 | 4.52 | 1.41 | 6.07 |
| 180 | 270 | | 31.4 | 46.0 | 0.70 | 4.73 | 1.44 | 6.21 |
| Total | | 313.5 | 378.0 | 468.8 | | | | |

TABLE XII Animal No. 89 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed: Whole Milk | Feed Consumed: Grain | Feed Consumed: Hay | Nutrients Required: Digestible Protein | Nutrients Required: T. D. N | Nutrients Consumed: Digestible Protein | Nutrients Consumed: T. D. N. |
|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 52 | | | | 0.17 | 0.99 | | |
| 5 | 53 | 18.6 | | | 0.17 | 1.01 | 0.12 | 0.74 |
| 15 | 54 | 42.7 | 1.5 | | 0.17 | 1.03 | 0.17 | 0.81 |
| 25 | 58 | 54.7 | 3.3 | | 0.19 | 1.10 | 0.25 | 1.16 |
| 35 | 62 | 51.2 | 5.6 | | 0.20 | 1.18 | 0.29 | 1.29 |
| 45 | 67 | 34.0 | 10.2 | 8.8 | 0.21 | 1.27 | 0.41 | 1.85 |
| 55 | 85 | | 17.8 | 17.8 | 0.27 | 1.62 | 0.56 | 2.40 |
| 65 | 94 | | 21.6 | 22.0 | 0.30 | 1.79 | 0.68 | 2.93 |
| 75 | 106 | | 25.4 | 26.8 | 0.34 | 2.01 | 0.81 | 3.49 |
| 85 | 116 | | 28.8 | 28.0 | 0.37 | 2.20 | 0.90 | 3.83 |
| 95 | 130 | | 30.0 | 26.2 | 0.42 | 2.47 | 0.91 | 3.84 |
| 105 | 140 | | 31.5 | 28.6 | 0.45 | 2.66 | 0.96 | 4.09 |
| 115 | 155 | | 31.8 | 30.0 | 0.45 | 2.87 | 0.99 | 4.19 |
| 125 | 168 | | 35.0 | 30.0 | 0.49 | 3.11 | 1.06 | 4.46 |
| 135 | 184 | | 35.0 | 33.5 | 0.53 | 3.40 | 1.10 | 4.64 |
| 145 | 200 | | 40.0 | 39.5 | 0.58 | 3.70 | 1.26 | 5.36 |
| 155 | 213 | | 43.5 | 42.5 | 0.62 | 3.94 | 1.36 | 5.80 |
| 165 | 227 | | 45.0 | 50.0 | 0.66 | 4.20 | 1.48 | 6.32 |
| 175 | 234 | | 45.0 | 50.0 | 0.68 | 4.33 | 1.48 | 6.32 |
| 180 | 237 | | 15.0 | 20.0 | 0.69 | 4.38 | 1.06 | 4.56 |
| Total | | 201.2 | 466.0 | 453.7 | | | | |

TABLE XIII Animal No. 159 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed: Whole Milk | Feed Consumed: Grain | Feed Consumed: Hay | Nutrients Required: Digestible Protein. | Nutrients Required: T. D. N | Nutrients Consumed: Digestible Protein. | Nutrients Consumed: T. D. N. |
|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 99 | | | | 0.32 | 1.88 | | |
| 5 | 99 | 32 | | | 0.32 | 1.88 | 0.21 | 1.04 |
| 15 | 106 | 93 | 1.9 | | 0.34 | 2.01 | 0.35 | 1.67 |
| 25 | 114 | 90 | 2.3 | 1.7 | 0.36 | 2.12 | 0.37 | 1.67 |
| 35 | 128 | 90 | 2.6 | 5.4 | 0.41 | 2.43 | 0.41 | 1.96 |
| 45 | 137 | 48 | 4.1 | 10.4 | 0.44 | 2.60 | 0.36 | 1.66 |
| 55 | 142 | | 6.0 | 16.8 | 0.45 | 2.70 | 0.31 | 1.37 |
| 65 | 152 | | 11.4 | 20.0 | 0.44 | 2.81 | 0.45 | 1.98 |
| 75 | 157 | | 14.0 | 36.0 | 0.46 | 2.90 | 0.67 | 3.02 |
| 85 | 180 | | 21.5 | 40.0 | 0.49 | 3.33 | 0.87 | 3.84 |
| 95 | 195 | | 25.5 | 45.0 | 0.57 | 3.61 | 1.02 | 4.44 |
| 105 | 208 | | 35.0 | 47.0 | 0.60 | 3.85 | 1.24 | 5.34 |
| 115 | 228 | | 40.0 | 46.0 | 0.66 | 4.22 | 1.33 | 5.69 |
| 125 | 250 | | 40.0 | 50.0 | 0.65 | 4.38 | 1.37 | 5.90 |
| 135 | 256 | | 36.5 | 56.5 | 0.67 | 4.48 | 1.37 | 5.95 |
| 145 | 268 | | 30.0 | 50.0 | 0.70 | 4.69 | 1.16 | 5.07 |
| 155 | 286 | | 35.0 | 50.0 | 0.74 | 5.01 | 1.27 | 5.49 |
| 165 | 300 | | 26.0 | 50.0 | 0.78 | 5.25 | 1.08 | 4.74 |
| 175 | 325 | | 26.5 | 57.5 | 0.85 | 5.69 | 1.17 | 5.17 |
| 180 | 336 | | 20.0 | 33.0 | 0.87 | 5.88 | 1.62 | 6.72 |
| Total | | 353 | 378.3 | 615.3 | | | | |

TABLE XIV Animal No. 161 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed Whole Milk | Feed Consumed Grain | Feed Consumed Hay | Nutrients Required Digestible Protein | Nutrients Required T. D. N | Nutrients Consumed Digestible Protein | Nutrients Consumed T. D. N. |
|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 84 | | | | 0.27 | 1.60 | | |
| 5 | 89 | 18.0 | | | 0.28 | 1.69 | 0.12 | 0.60 |
| 15 | 81 | 55.5 | 0.9 | | 0.26 | 1.54 | 0.20 | 0.97 |
| 25 | 87 | 60.0 | 4.2 | 1.6 | 0.28 | 1.65 | 0.31 | 1.40 |
| 35 | 91 | 60.0 | 3.2 | 5.3 | 0.29 | 1.73 | 0.33 | 1.51 |
| 45 | 108 | 28.0 | 5.5 | 14.0 | 0.35 | 2.05 | 0.36 | 1.63 |
| 55 | 123 | | 12.8 | 23.4 | 0.39 | 2.34 | 0.52 | 2.27 |
| 65 | 135 | | 16.0 | 30.0 | 0.43 | 2.57 | 0.66 | 2.88 |
| 75 | 146 | | 16.0 | 30.0 | 0.47 | 2.77 | 0.66 | 2.88 |
| 85 | 161 | | 21.6 | 29.7 | 0.47 | 2.98 | 0.77 | 3.32 |
| 95 | 171 | | 24.7 | 37.6 | 0.50 | 3.16 | 0.92 | 3.99 |
| 105 | 184 | | 29.4 | 40.0 | 0.53 | 3.40 | 1.04 | 4.50 |
| 115 | 198 | | 30.2 | 42.5 | 0.57 | 3.66 | 1.08 | 4.70 |
| 125 | 220 | | 30.0 | 45.0 | 0.64 | 4.07 | 1.11 | 4.81 |
| 135 | 234 | | 31.0 | 45.0 | 0.68 | 4.33 | 1.13 | 4.89 |
| 145 | 256 | | 36.0 | 46.5 | 0.67 | 4.48 | 1.25 | 5.39 |
| 155 | 271 | | 40.0 | 50.0 | 0.70 | 4.74 | 1.37 | 5.90 |
| 165 | 289 | | 40.0 | 61.0 | 0.75 | 5.06 | 1.49 | 6.47 |
| 175 | 304 | | 34.0 | 61.0 | 0.79 | 5.32 | 1.36 | 5.97 |
| 180 | 312 | | 20.0 | 35.0 | 0.81 | 5.46 | 1.58 | 6.95 |
| Total | | 221.5 | 395.5 | 597.6 | | | | |

TABLE XV Animal No. 162 showing feed consumed by 10 day periods from birth to 180 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed Whole Milk | Feed Consumed Grain | Feed Consumed Hay | Nutrients Required Digestible Protein. | Nutrients Required T. D. N | Nutrients Consumed Digestible Protein. | Nutrients Consumed T. D. N. |
|---|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 0 | 86 | | | | 0.28 | 1.63 | | |
| 11 | 95 | 57.0 | 0.7 | 0.7 | 0.30 | 1.81 | 0.20 | 0.93 |
| 21 | 98 | 57.5 | 2.0 | 3.0 | 0.31 | 1.86 | 0.26 | 1.25 |
| 31 | 110 | 60.0 | 4.2 | 5.6 | 0.35 | 2.09 | 0.35 | 1.61 |
| 41 | 119 | 36.0 | 8.4 | 14.2 | 0.38 | 2.26 | 0.45 | 2.01 |
| 51 | 114 | 1.0 | 7.2 | 10.6 | 0.36 | 2.17 | 0.27 | 1.17 |
| 61 | 104 | 57.0 | 0.2 | 0.1 | 0.33 | 1.98 | 0.20 | 0.95 |
| 68 | | 49.0 | | | | | 0.26 | 1.31 |
| Total | | 317.5 | 22.7 | 34.2 | | | | |

Died of pneumonia May 6, 1930.

TABLE XVI Lot I showing a summary of the feed consumption from birth to 180 days of age.

| Animal No. | Breed | Whole Milk | Average* Daily Intake | Skim Milk | Average* Daily Intake | Grain | Average* Daily Intake | Hay | Average* Daily Intake |
|---|---|---|---|---|---|---|---|---|---|
| | | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 87 | Jersey | 184.9 | 5.28 | 1,768 | 12.9 | 263.1 | 1.6 | 297 | 1.9 |
| 88 | Jersey | 185.9 | 5.99 | 1,945.6 | 12.4 | 293.8 | 1.7 | 371.4 | 2.2 |
| 131 | Ayrshire | 272.5 | 6.81 | 2,310 | 15.8 | 305.8 | 2.0 | 524.4 | 3.7 |
| 160 | Holstein | 241.1 | 7.77 | 2,313.5 | 15.4 | 349.7 | 2.0 | 508.7 | 3.0 |
| 181 | Holstein | 265.2 | 7.16 | 2,442 | 15.9 | 417.9 | 2.5 | 577.6 | 3.4 |
| Total | | 1,149.6 | | 10,779.1 | | 1,630.3 | | 2,279.1 | |
| Av. per animal | | 229.9 | | 2,155.8 | | 326.1 | | 455.8 | |

* Calculated from the actual number of days fed.

TABLE XVII Lot II showing a summary of the feed consumption from birth to 180 days of age.

| Animal No. | Breed | Whole Milk | Average* Daily Intake | Grain | Average* Daily Intake | Hay | Average* Daily Intake |
|---|---|---|---|---|---|---|---|
| | | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 9's Bu | Guernsey | 180 | 5.1 | 450.4 | 3.0 | 496.7 | 3.3 |
| 90 | Jersey | 140 | 4.0 | 337 | 2.0 | 460 | 2.7 |
| 163** | Holstein | 344 | 6.7 | 80.6 | 1.0 | 219.9 | 2.7 |
| 164 | Holstein | 140.5 | 4.7 | 488.7 | 2.8 | 636.2 | 3.7 |
| 166 | Holstein | 135.5 | 4.5 | 478.9 | 2.8 | 598.6 | 3.5 |
| Total | | 596.0 | (Excluding 163) | 1,755.0 | | 2,191.5 | |
| Av. per animal | | 149 | | 438.8 | | 547.9 | |

** Died June 20, 1930.

* Calculated from the actual number of days fed.

TABLE XVIII    Lot III showing a summary of the feed consumption from birth to 180 days of age.

| Animal No. | Breed | Whole Milk | Average* Daily Intake | Grain | Average* Daily Intake | Hay | Average* Daily Intake |
|---|---|---|---|---|---|---|---|
| | | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 24 | Guernsey | 313.5 | 7.0 | 378.0 | 2.2 | 468.8 | 2.7 |
| 89 | Jersey | 201.2 | 4.6 | 466.0 | 2.7 | 453.7 | 4.3 |
| 159 | Holstein | 353.0 | 8.0 | 378.3 | 2.2 | 615.3 | 3.7 |
| 161 | Holstein | 221.5 | 5.3 | 395.5 | 2.3 | 597.6 | 3.7 |
| 162** | Holstein | 317.5 | 6.1 | 22.7 | .6 | 34.2 | .8 |
| Total | | 1,089.2 | (Excluding 162) | 1,617.8 | | 2,135.4 | |
| Av. per animal | | 272.3 | | 404.5 | | 533.9 | |

** Died May 6, 1930.

* Calculated from the actual number of days fed.

TABLE XIX Animal No. 87 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed | | Nutrients Required | | Nutrients Consumed | |
|---|---|---|---|---|---|---|---|
| | | Grain | Hay | Digestible Protein. | T. D. N | Digestible Protein. | T. D. N. |
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 277 | | | | | | |
| 206 | 320 | 67 | 88 | 0.74 | 4.96 | 0.75 | 4.03 |
| 236 | 378 | 90 | 170 | 0.76 | 5.48 | 1.05 | 5.04 |
| 266 | 404 | 99 | 213 | 0.81 | 5.86 | 1.24 | 6.09 |
| 296 | 443 | 120 | 240 | 0.89 | 6.42 | 1.44 | 7.08 |
| 326 | 491 | 120 | 240 | 0.88 | 6.78 | 1.44 | 7.08 |
| 356 | 504 | 120 | 240 | 0.91 | 6.96 | 1.44 | 7.08 |
| 360 | 507 | 16 | 36 | 0.96 | 7.38 | 1.54 | 7.20 |
| Total | 230 | 632 | 1,227 | | | | |
| Daily Av. | 1.28 | 3.51 | 6.81 | | | | |

TABLE XX Animal No. 88 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for per- iod | Av. body wt. | Feed Consumed | | Nutrients Required | | Nutrients Consumed | |
|---|---|---|---|---|---|---|---|
| | | Grain | Hay | Digestible Protein. | T. D. N | Digestible Protein. | T. D. N. |
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 307 | | | | | | |
| 213 | 359 | 98 | 182 | 0.72 | 5.21 | 1.03 | 5.03 |
| 243 | 399 | 101 | 219 | 0.80 | 5.79 | 1.27 | 6.25 |
| 273 | 420 | 120 | 240 | 0.84 | 6.09 | 1.44 | 7.08 |
| 303 | 470 | 120 | 240 | 0.85 | 6.49 | 1.44 | 7.08 |
| 333 | 486 | 120 | 240 | 0.87 | 6.71 | 1.44 | 7.08 |
| 360 | 493 | 108 | 232 | 0.89 | 6.80 | 1.44 | 7.36 |
| Total | 186 | 667 | 1,353 | | | | |
| Daily Av. | 1.03 | 3.71 | 7.52 | | | | |

TABLE XXI Animal No. 131 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed | | Nutrients Required | | Nutrients Consumed | |
|---|---|---|---|---|---|---|---|
| | | Grain | Hay | Digestible Protein. | T. D. N | Digestible Protein. | T. D. N |
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 358 | | | | | | |
| 218 | 418 | 140 | 199 | 0.75 | 6.06 | 1.10 | 5.41 |
| 248 | 494 | 120 | 222 | 0.89 | 6.82 | 1.38 | 6.76 |
| 278 | 525 | 130 | 279 | 0.95 | 7.25 | 1.65 | 7.99 |
| 308 | 554 | 150 | 300 | 0.94 | 7.20 | 1.81 | 8.84 |
| 338 | 602 | 150 | 300 | 1.02 | 7.83 | 1.81 | 8.84 |
| 360 | 621 | 110 | 220 | 1.06 | 8.07 | 1.81 | 8.84 |
| Total | 263 | 800 | 1,520 | | | | |
| Daily Av. | 1.46 | 4.44 | 8.44 | | | | |

TABLE XXII Animal No. 160 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed | | Nutrients Required | | Nutrients Consumed | |
|---|---|---|---|---|---|---|---|
| | | Grain | Hay | Digestible Protein. | T. D. N | Digestible Protein. | T. D. N. |
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 406 | | | | | | |
| 205 | 468 | 88 | 159 | 0.84 | 6.46 | 1.19 | 5.88 |
| 235 | 503 | 120 | 250 | 0.91 | 6.94 | 1.47 | 7.24 |
| 265 | 548 | 150 | 269 | 0.99 | 7.56 | 1.79 | 8.78 |
| 295 | 607 | 150 | 300 | 1.03 | 7.89 | 1.80 | 8.85 |
| 325 | 632 | 150 | 300 | 1.07 | 8.22 | 1.80 | 8.85 |
| 355 | 670 | 150 | 300 | 1.07 | 8.04 | 1.80 | 8.85 |
| 360 | 679 | 25 | 50 | 1.09 | 8.15 | 1.80 | 8.85 |
| Total | 273 | 833 | 1,628 | | | | |
| Daily Av. | 1.52 | 4.63 | 9.04 | | | | |

TABLE XXIII Animal No. 181 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed | | Nutrients Required | | Nutrients Consumed | |
|---|---|---|---|---|---|---|---|
| | | Grain | Hay | Digestible Protein. | T. D. N | Digestible Protein. | T. D. N. |
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 378 | | | | | | |
| 199 | 403 | 76 | 133 | 0.81 | 5.84 | 1.33 | 6.56 |
| 229 | 438 | 120 | 210 | 0.88 | 6.35 | 1.33 | 6.56 |
| 259 | 477 | 120 | 237 | 0.86 | 6.58 | 1.43 | 7.02 |
| 289 | 519 | 133 | 264 | 0.93 | 7.16 | 1.59 | 7.80 |
| 319 | 565 | 150 | 270 | 0.96 | 7.35 | 1.69 | 8.32 |
| 349 | 619 | 165 | 270 | 1.05 | 8.05 | 1.77 | 8.69 |
| 360 | 640 | 55 | 99 | 1.09 | 8.32 | 1.69 | 8.32 |
| Total | 262 | 819 | 1,483 | | | | |
| Daily Av. | 1.46 | 4.55 | 8.24 | | | | |

TABLE XXIV Animal No. 90 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for per-iod | Av. body wt. | Feed Consumed Grain | Feed Consumed Hay | Nutrients Required Digestible Protein. | Nutrients Required T. D. N | Nutrients Consumed Digestible Protein. | Nutrients Consumed T. D. N. |
|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 210 | | | | | | |
| 208 | 242 | 113 | 154 | 0.63 | 4.00 | 0.99 | 5.75 |
| 238 | 281 | 120 | 165 | 0.65 | 4.36 | 0.99 | 5.75 |
| 268 | 316 | 120 | 179 | 0.73 | 4.90 | 1.04 | 5.99 |
| 298 | 340 | 123 | 204 | 0.78 | 5.27 | 1.13 | 6.49 |
| 328 | 375 | 135 | 225 | 0.75 | 5.44 | 1.26 | 7.15 |
| 358 | 423 | 159 | 240 | 0.85 | 6.13 | 1.39 | 7.99 |
| 360 | 425 | 10.6 | 16 | 0.85 | 6.16 | 1.35 | 7.43 |
| Total | 215 | 780.6 | 1,183 | | | | |
| Daily Av. | 1.19 | 4.34 | 6.57 | | | | |

TABLE XXV Animal No. 164 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for per-iod | Av. body wt. | Feed Consumed Grain | Feed Consumed Hay | Nutrients Required Digestible Protein. | Nutrients Required T. D. N | Nutrients Consumed Digestible Protein. | Nutrients Consumed T. D. N. |
|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 322 | | | | | | |
| 206 | 390 | 130 | 156 | 0.78 | 5.66 | 1.15 | 6.74 |
| 236 | 454 | 150 | 201 | 0.82 | 6.27 | 1.22 | 7.10 |
| 266 | 506 | 150 | 228 | 0.91 | 6.98 | 1.31 | 7.56 |
| 296 | 560 | 150 | 267 | 0.95 | 7.28 | 1.45 | 8.23 |
| 326 | 582 | 150 | 270 | 0.99 | 7.57 | 1.46 | 8.28 |
| 356 | 636 | 176 | 270 | 1.08 | 8.27 | 1.55 | 8.91 |
| 360 | 640 | 25 | 40 | 1.09 | 8.32 | 1.69 | 9.63 |
| Total | 308 | 931 | 1,432 | | | | |
| Daily Av. | 1.71 | 5.17 | 7.95 | | | | |

TABLE XXVI Animal No. 166 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed | | Nutrients Required | | Nutrients Consumed | |
|---|---|---|---|---|---|---|---|
| | | Grain | Hay | Digestible Protein. | T. D. N | Digestible Protein. | T. D. N. |
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 302 | | | | | | |
| 207 | 351 | 130 | 162 | 0.70 | 5.09 | 1.15 | 6.60 |
| 237 | 392 | 150 | 180 | 0.78 | 5.68 | 1.15 | 6.60 |
| 267 | 443 | 150 | 207 | 0.89 | 6.42 | 1.24 | 7.20 |
| 297 | 484 | 150 | 234 | 0.87 | 6.68 | 1.33 | 7.66 |
| 327 | 543 | 164 | 240 | 0.98 | 7.49 | 1.40 | 8.11 |
| 357 | 586 | 180 | 269 | 1.00 | 7.62 | 1.56 | 8.99 |
| 360 | 590 | 18 | 27 | 1.00 | 7.67 | 1.56 | 8.99 |
| Total | 288 | 942 | 1,319 | | | | |
| Daily Av. | 1.60 | 5.23 | 7.32 | | | | |

TABLE XXVII  Animal No. 24 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed Grain | Feed Consumed Hay | Nutrients Required Digestible Protein | Nutrients Required T. D. N | Nutrients Consumed Digestible Protein | Nutrients Consumed T. D. N. |
|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 270 | | | | | | |
| 202 | 313 | 88 | 132 | 0.72 | 4.85 | 1.25 | 6.23 |
| 232 | 348 | 120 | 180 | 0.80 | 5.39 | 1.25 | 6.30 |
| 262 | 382 | 120 | 207 | 0.76 | 5.54 | 1.34 | 6.76 |
| 292 | 431 | 120 | 234 | 0.86 | 6.25 | 1.44 | 7.22 |
| 322 | 476 | 120 | 240 | 0.86 | 6.57 | 1.46 | 7.33 |
| 352 | 527 | 135 | 269 | 0.95 | 7.27 | 1.64 | 8.22 |
| 360 | 535 | 36 | 72 | 0.96 | 7.38 | 1.65 | 8.24 |
| Total | 265 | 739 | 1,334 | | | | |
| Daily Av. | 1.47 | 4.11 | 7.41 | | | | |

TABLE XXVIII Animal No. 89 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed | | Nutrients Required | | Nutrients Consumed | |
|---|---|---|---|---|---|---|---|
| | | Grain | Hay | Digestible Protein. | T. D. N | Digestible Protein. | T. D. N. |
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 237 | | | | | | |
| 185 | 240 | 15 | 20 | 0.62 | 3.96 | 1.06 | 4.56 |
| 215 | 293 | 120 | 172 | 0.67 | 4.54 | 1.22 | 6.16 |
| 245 | 330 | 120 | 236 | 0.76 | 5.12 | 1.41 | 7.26 |
| 275 | 379 | 120 | 240 | 0.76 | 5.50 | 1.46 | 7.33 |
| 305 | 417 | 120 | 240 | 0.83 | 6.05 | 1.46 | 7.33 |
| 335 | 431 | 120 | 240 | 0.86 | 6.25 | 1.46 | 7.33 |
| 360 | 464 | 100 | 200 | 0.84 | 6.40 | 1.46 | 7.33 |
| Total | 227 | 715 | 1,348 | | | | |
| Daily Av. | 1.26 | 3.97 | 7.49 | | | | |

TABLE XXIX  Animal No. 159 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed Grain | Feed Consumed Hay | Nutrients Required Digestible Protein. | Nutrients Required T. D. N | Nutrients Consumed Digestible Protein. | Nutrients Consumed T. D. N. |
|---|---|---|---|---|---|---|---|
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 336 | | | | | | |
| 185 | 347 | 20 | 33 | 0.80 | 5.37 | 1.32 | 6.6 |
| 215 | 407 | 120 | 255 | 0.81 | 5.90 | 1.53 | 7.56 |
| 245 | 457 | 114 | 271 | 0.82 | 6.30 | 1.54 | 7.69 |
| 275 | 504 | 120 | 300 | 0.91 | 7.00 | 1.68 | 8.36 |
| 305 | 569 | 120 | 300 | 0.97 | 7.40 | 1.68 | 8.36 |
| 335 | 574 | 120 | 300 | 0.98 | 7.46 | 1.68 | 8.36 |
| 360 | 597 | 100 | 250 | 1.02 | 7.76 | 1.68 | 8.36 |
| Total | 261 | 714 | 1,709 | | | | |
| Daily Av. | 1.45 | 3.97 | 9.49 | | | | |

TABLE XXX  Animal No. 161 showing feed consumed by 30 day periods from 180 to 360 days of age. Average daily requirements and consumption of Digestible Protein and total Digestible Nutrients according to the Morrison Standard.

| Age for period | Av. body wt. | Feed Consumed | | Nutrients Required | | Nutrients Consumed | |
|---|---|---|---|---|---|---|---|
| | | Grain | Hay | Digestible Protein. | T. D. N | Digestible Protein. | T. D. N. |
| Days | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 180 | 312 | | | | | | |
| 185 | 325 | 20 | 35 | 0.75 | 5.04 | 1.36 | 6.80 |
| 205 | 356 | 120 | 219 | 0.71 | 5.16 | 1.39 | 6.96 |
| 235 | 408 | 120 | 266 | 0.82 | 5.92 | 1.56 | 7.78 |
| 265 | 471 | 120 | 270 | 0.85 | 6.50 | 1.57 | 7.84 |
| 295 | 515 | 120 | 270 | 0.93 | 7.11 | 1.57 | 7.84 |
| 325 | 564 | 120 | 270 | 0.96 | 7.32 | 1.57 | 7.84 |
| 355 | 602 | 120 | 294 | 1.02 | 7.85 | 1.66 | 8.26 |
| 360 | 612 | 22 | 50 | 1.04 | 7.96 | 1.75 | 8.73 |
| Total | 300 | 762 | 1,674 | | | | |
| Daily Av. | 1.67 | 4.23 | 9.3 | | | | |

TABLE XXXI showing the feed consumed from birth to 180 days.

Lot I

| Animal Number | Breed | Whole Milk | Skim Milk | Grain | Hay |
|---|---|---|---|---|---|
| | | Lbs. | Lbs. | Lbs. | Lbs. |
| 87 | Jersey | 184.9 | 1,768.6 | 263.1 | 297.0 |
| 88 | Jersey | 185.9 | 1,945.6 | 293.8 | 371.4 |
| 151 | Ayrshire | 272.5 | 2,310.0 | 305.8 | 524.4 |
| 160 | Holstein | 241.1 | 2,313.5 | 394.7 | 508.7 |
| 181 | Holstein | 265.2 | 2,442.0 | 417.9 | 577.6 |
| Total | | 1,149.6 | 10,779.7 | 1,675.3 | 2,277.1 |
| Average per animal | | 229.9 | 2,155.9 | 335.0 | 455.4 |

Lot II

| Animal Number | Breed | Whole Milk | Skim Milk | Grain | Hay |
|---|---|---|---|---|---|
| 9's Bu | Guernsey | 180.0 | | 450.4 | 496.7 |
| 90 | Jersey | 140.0 | | 337.0 | 460.0 |
| 164 | Holstein | 140.5 | | 488.7 | 636.2 |
| 166 | Holstein | 135.5 | | 478.9 | 598.6 |
| Total | | 596.0 | | 1,755.0 | 2,191.5 |
| Average per animal | | 149.0 | | 438.7 | 547.8 |

Lot III

| Animal Number | Breed | Whole Milk | Skim Milk | Grain | Hay |
|---|---|---|---|---|---|
| 24 | Guernsey | 313.5 | | 378.0 | 468.8 |
| 89 | Jersey | 201.2 | | 466.0 | 453.7 |
| 159 | Holstein | 353.0 | | 378.3 | 615.3 |
| 161 | Holstein | 221.5 | | 395.5 | 597.6 |
| Total | | 1,089.2 | | 1,617.8 | 2,135.4 |
| Average per animal | | 272.3 | | 404.4 | 533.8 |

TABLE XXXII showing the amount of feed consumed from 180 to 360 days of age.

Lot I

| Animal Number | Breed | Grain | Hay |
|---|---|---|---|
| | | Lbs. | Lbs. |
| 87 | Jersey | 632 | 1,227 |
| 88 | Jersey | 667 | 1,353 |
| 151 | Ayrshire | 800 | 1,520 |
| 160 | Holstein | 833 | 1,628 |
| 181 | Holstein | 819 | 1,483 |
| Total | | 3,751 | 7,211 |
| Average per animal | | 750.2 | 1,442.2 |

Lot II

| | | | |
|---|---|---|---|
| 9's Bull* | Guernsey | | |
| 90 | Jersey | 780.6 | 1,183 |
| 164 | Holstein | 931.0 | 1,432 |
| 166 | Holstein | 942.0 | 1,319 |
| Total | | 2,653.6 | 3,934 |
| Average per animal | | 884.5 | 1,311.3 |

* Sold at 180 days of age.

Lot III

| | | | |
|---|---|---|---|
| 24 | Guernsey | 739 | 1,334 |
| 89 | Jersey | 715 | 1,348 |
| 159 | Holstein | 714 | 1,709 |
| 161 | Holstein | 762 | 1,674 |
| Total | | 2,930 | 6,065 |
| Average per animal | | 732.5 | 1,516.2 |

TABLE XXXIII showing the total gain, average gain and average daily gain per animal and per lot from birth to 180 days and from 180 to 360 days of age.

Lot I

| Animal No. | Breed | Birth Weight | Wt. 180 Days | Gain | Average Daily Gain | Wt. 360 Days | Gain from 180 days | Average Daily Gain |
|---|---|---|---|---|---|---|---|---|
| | | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. | Lbs. |
| 87 | Jersey | 55 | 277 | 222 | 1.23 | 507 | 230 | 1.28 |
| 88 | Jersey | 54 | 307 | 253 | 1.41 | 493 | 186 | 1.03 |
| 151 | Ayrshire | 73 | 358 | 285 | 1.58 | 621 | 263 | 1.46 |
| 160 | Holstein | 90 | 406 | 316 | 1.76 | 679 | 273 | 1.52 |
| 181 | Holstein | 86 | 378 | 292 | 1.62 | 640 | 262 | 1.46 |
| Total | | 358 | 1,726 | 1,368 | | 2,940 | 1,214 | |
| Av. per animal | | 71.6 | 345.2 | 273.6 | 1.52 | 588 | 242.8 | 1.35 |

Lot II

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9's Bu* | Guernsey | 71 | 299 | 228 | 1.27 | | | |
| 90 | Jersey | 56 | 210 | 154 | .87 | 425 | 215 | 1.19 |
| 163** | Holstein | 90 | | | | | | |
| 164 | Holstein | 100 | 332 | 232 | 1.29 | 640 | 308 | 1.71 |
| 166 | Holstein | 88 | 302 | 214 | 1.19 | 590 | 288 | 1.60 |
| Total | | 405 | 1,143 | 828 | | 1,655 | 811 | |
| Av. per animal | | 81 | 285.7 | 207 | 1.15 | 413.1 | 270.3 | 1.50 |

Lot III

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 24 | Guernsey | 65 | 270 | 205 | 1.14 | 535 | 265 | 1.47 |
| 89 | Jersey | 52 | 237 | 185 | 1.03 | 464 | 227 | 1.26 |
| 159 | Holstein | 99 | 336 | 237 | 1.32 | 597 | 261 | 1.45 |
| 161 | Holstein | 84 | 312 | 228 | 1.27 | 612 | 300 | 1.67 |
| 162** | Holstein | 86 | | | | | | |
| Total | | 386 | 1,155 | 855 | | 2,208 | 1,053 | |
| Av. per animal | | 77.2 | 288.8 | 213.8 | 1.19 | 552 | 263.3 | 1.46 |

* Sold at 180 days of age.

** Died during experiment.

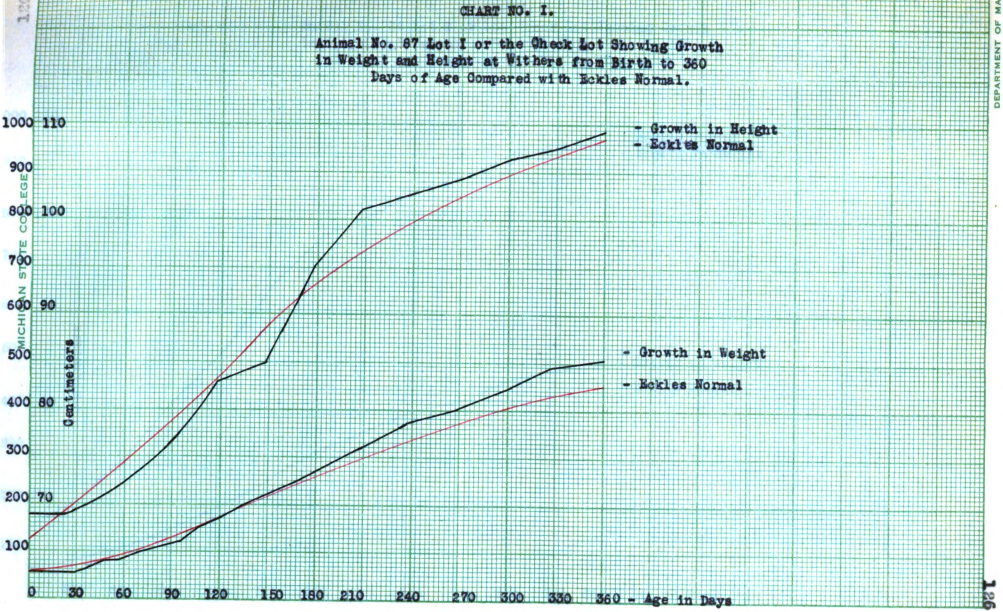


CHART NO. I.
Animal No. 87 Lot I or the Check Lot Showing Growth in Weight and Height at Withers from Birth to 360 Days of Age Compared with Eckles Normal.
- Growth in Height
- Eckles Normal
- Growth in Weight
- Eckles Normal
Centimeters
1000 110
900
800 100
700
600 90
500
400 80
300
200 70
100
0 30 60 90 120 150 180 210 240 270 300 330 360 - Age in Days

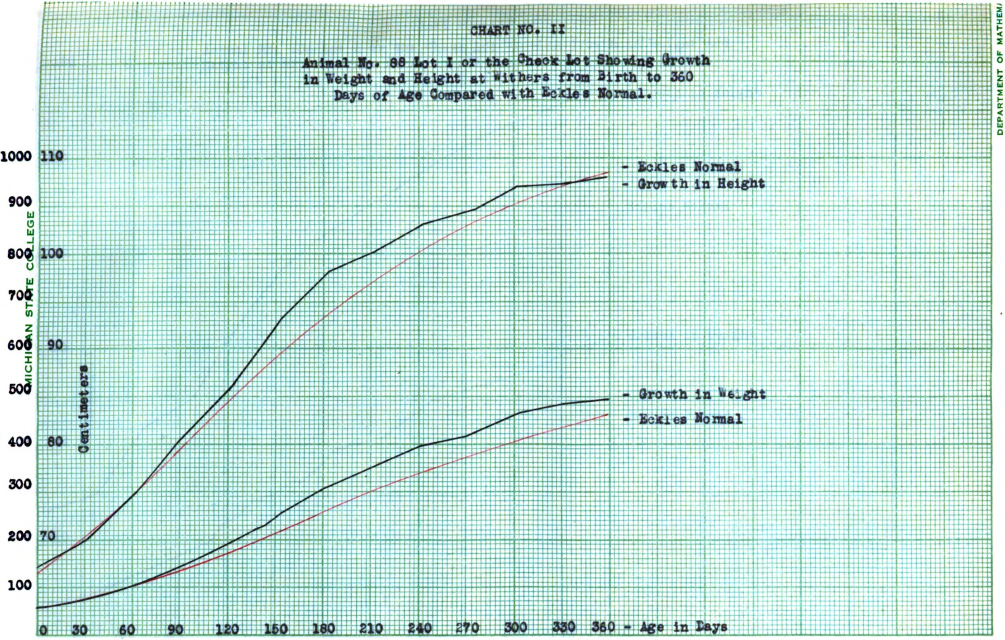


CHART NO. II
Animal No. 88 Lot I or the Check Lot Showing Growth
in Weight and Height at Withers from Birth to 360
Days of Age Compared with Eckles Normal.
- Eckles Normal
- Growth in Height
- Growth in Weight
- Eckles Normal
Centimeters
1000
900
800
700
600
500
400
300
200
100
110
100
90
80
70
0
30
60
90
120
150
180
210
240
270
300
330
360 - Age in Days
MICHIGAN STATE COLLEGE
DEPARTMENT OF MATHEM

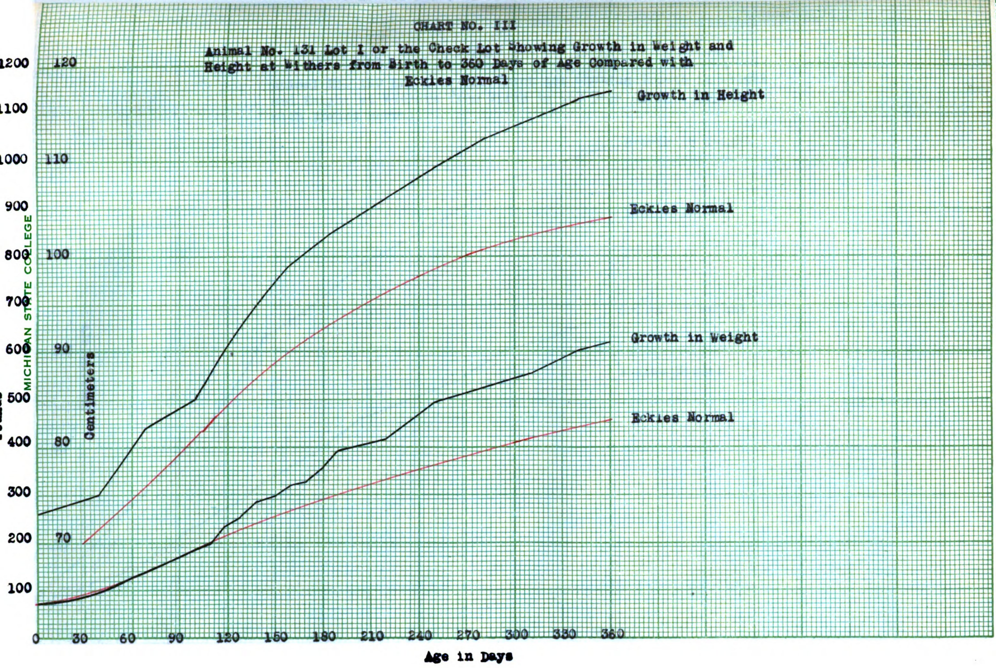


CHART NO. III
Animal No. 131 Lot I or the Check Lot Showing Growth in Weight and Height at Withers from Birth to 360 Days of Age Compared with Eckles Normal
Growth in Height
Eckles Normal
Growth in Weight
Eckles Normal
Centimeters
120
110
100
90
80
70
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
30
60
90
120
150
180
210
240
270
300
330
360
Age in Days

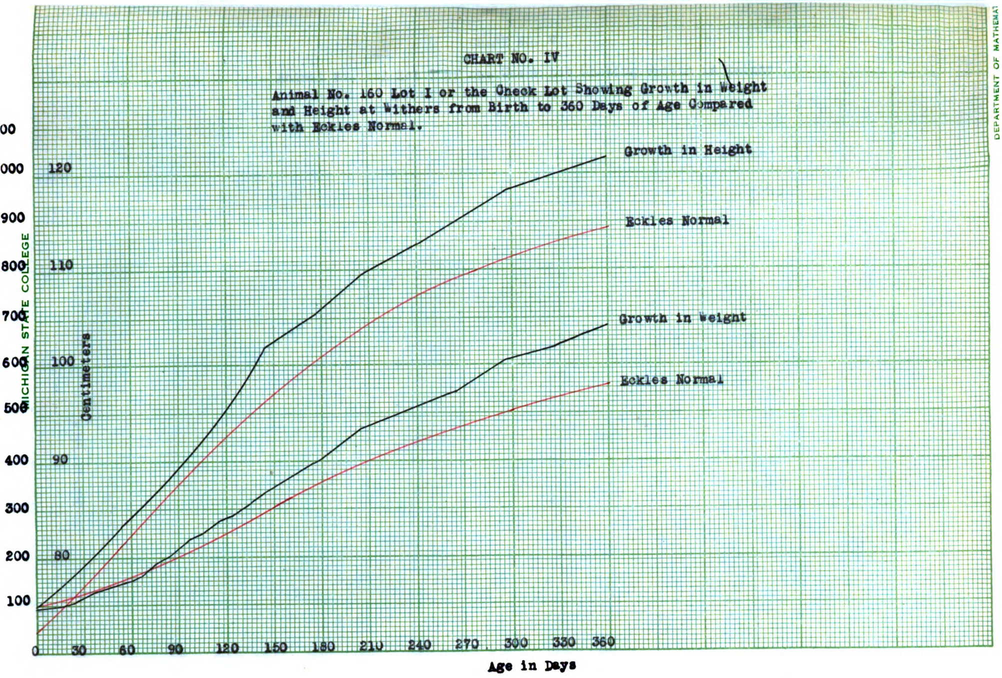


CHART NO. IV
Animal No. 160 Lot I or the Check Lot Showing Growth in Weight and Height at Withers from Birth to 360 Days of Age Compared with Eckles Normal.
Growth in Height
Eckles Normal
Growth in Weight
Eckles Normal
Centimeters
120
110
100
90
80
000
900
800
700
600
500
400
300
200
100
0
30
60
90
120
150
180
210
240
270
300
330
360
Age in Days
MICHIGAN STATE COLLEGE
DEPARTMENT OF MATHEMAT

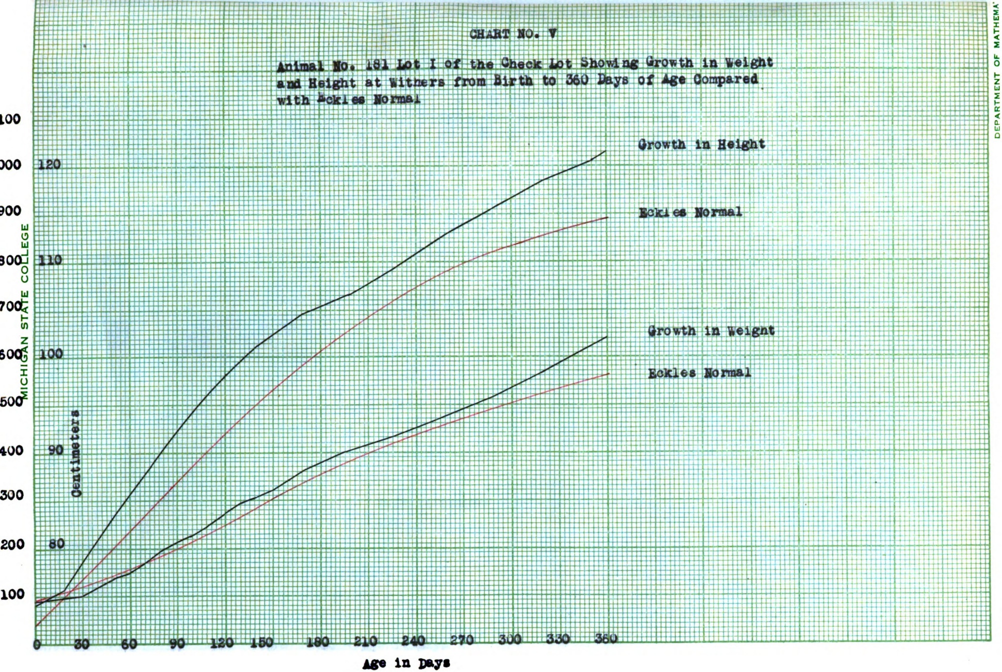
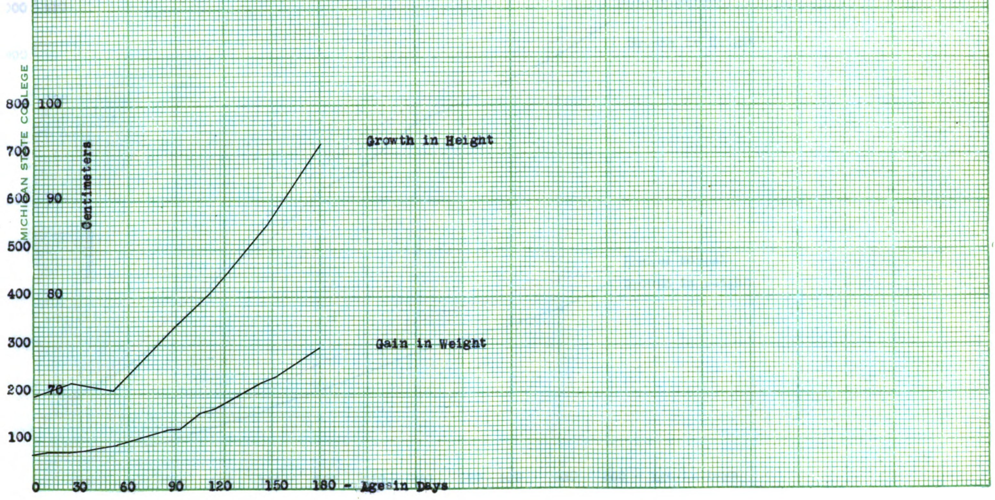


CHART NO. V
Animal No. 181 Lot I of the Check Lot Showing Growth in Weight and Height at Withers from Birth to 360 Days of Age Compared with Eckles Normal
Growth in Height
Eckles Normal
Growth in Weight
Eckles Normal
Centimeters
120
110
100
90
80
900
700
500
400
300
200
100
0
30
60
90
120
150
180
210
240
270
300
330
360
Age in Days
MICHIGAN STATE COLLEGE
DEPARTMENT OF MATHEMA

CHART NO. VI

Animal No. 9's Bull Lot II Fed According to the New Jersey System. Showing the Growth in Weight and Height at Withers from Birth to 180 Days of Age



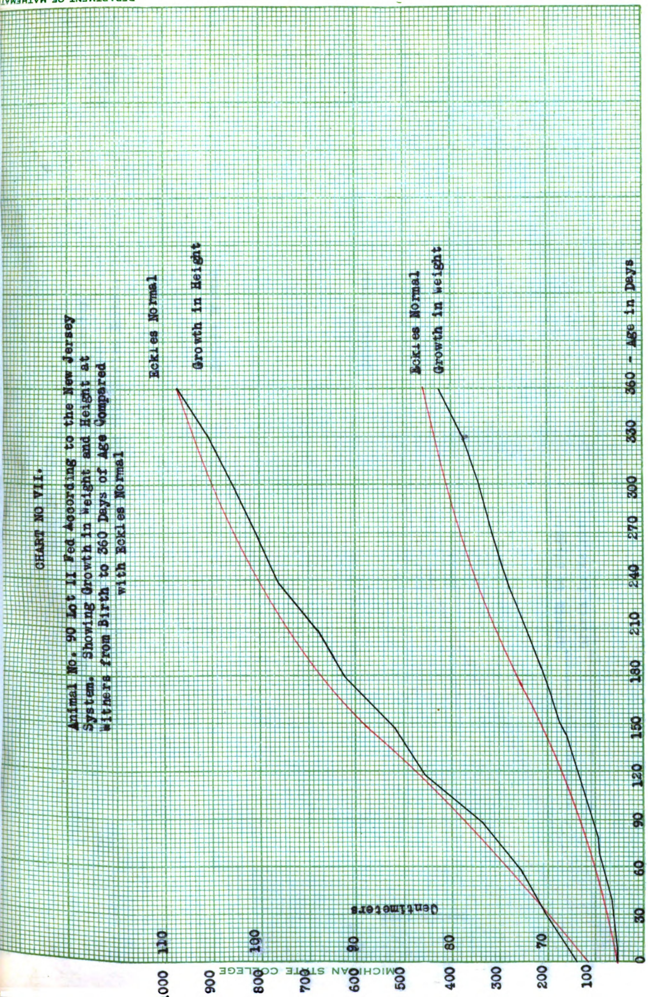
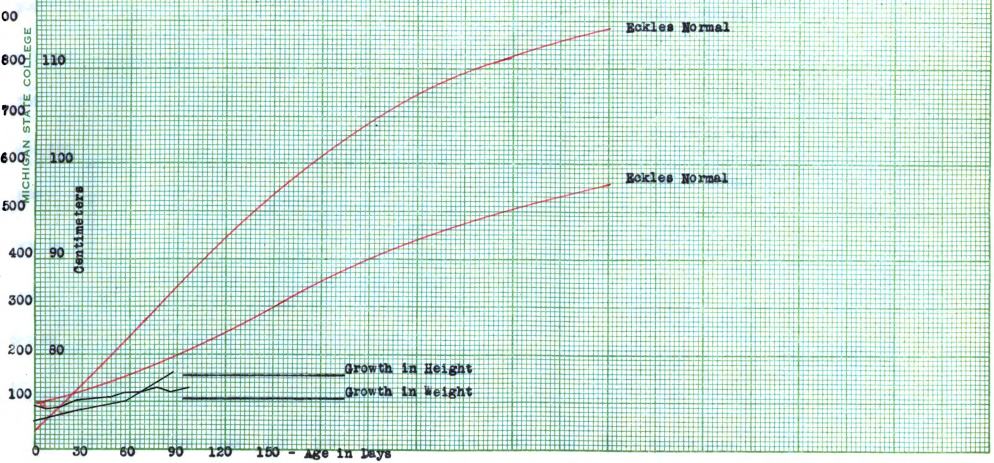


CHART NO VII.
Animal No. 90 Lot II Fed According to the New Jersey System. Showing Growth in Weight and Height at Withers from Birth to 360 Days of Age Compared with Eckles Normal
Eckles Normal
Growth in Height
Eckles Normal
Growth in Weight
360 - Age in Days
0
30
60
90
120
150
180
210
240
270
300
330
Centimeters
70
80
90
100
110
100
200
300
400
500
600
700
800
900
1000
DEPARTMENT OF MATHEMATI
MICHIGAN STATE COLLEGE

CHART NO. VIII

Animal No. 163 Lot II Fed According to the New Jersey System. Showing Growth in Weight and Height at Withers From Birth to Death Compared with Eckles Normal.



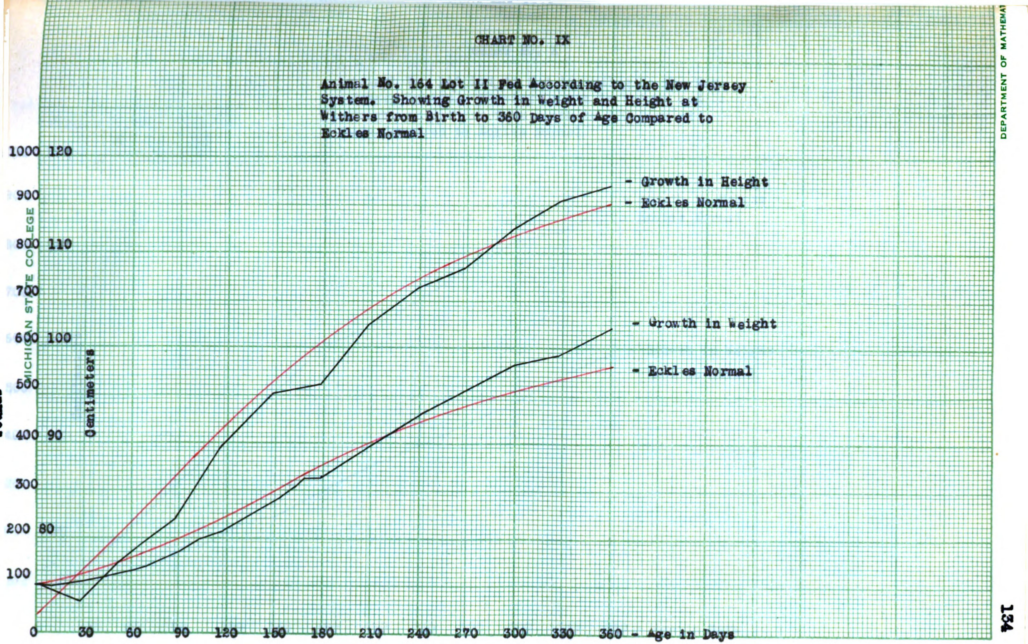


CHART NO. IX
Animal No. 164 Lot II Fed According to the New Jersey System. Showing Growth in Weight and Height at Withers from Birth to 360 Days of Age Compared to Eckles Normal
- Growth in Height
- Eckles Normal
- Growth in Weight
- Eckles Normal
Centimeters
1000 120
900
800 110
700
600 100
500
400 90
300
200 80
100
0
30
60
90
120
150
180
210
240
270
300
330
360 - Age in Days
MICHIGAN STATE COLLEGE
DEPARTMENT OF MATHEMAT

CHART NO. X

Animal No. 166 Lot II Fed According to the New Jersey System. Showing Growth in Weight and Height at Withers from Birth to 360 Days of Age Compared to Eckles Normal

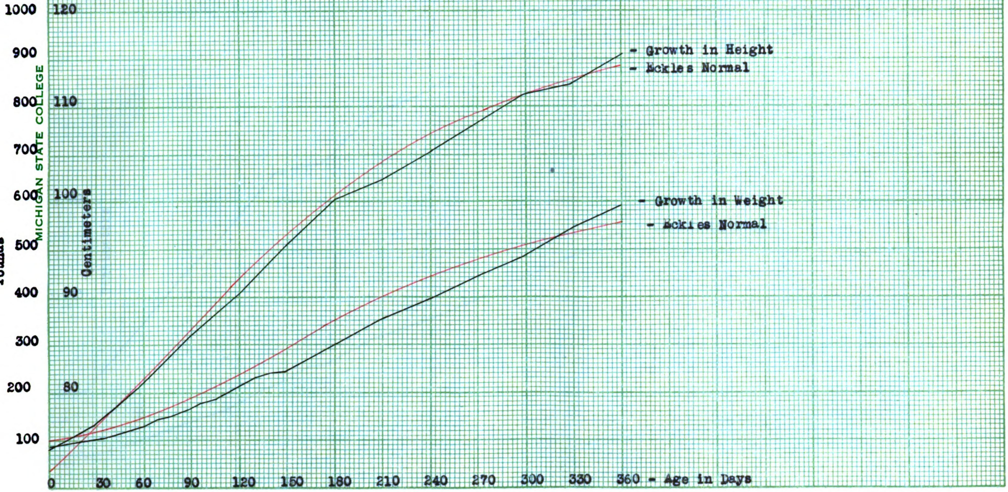


CHART NO. XI

Animal No. 24 Lot III Fed According to the M. S. C. System. Showing Growth in Weight and Height at Withers from Birth to 360 Days of Age.

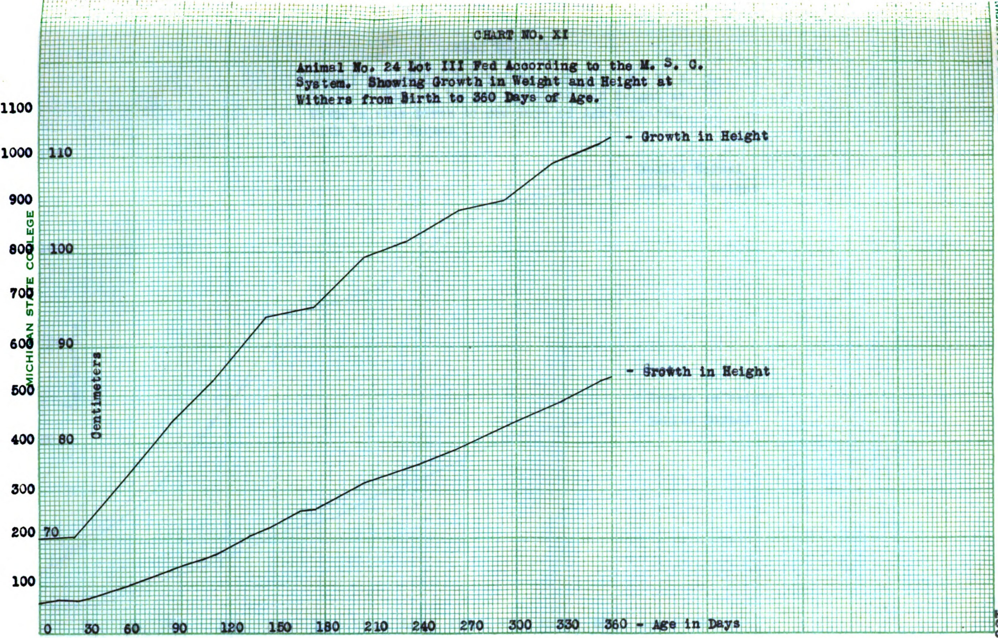


CHART NO. XII

Animal No. 89 Lot III Fed According to the M. S. C. System. Showing Growth in Weight and Height at Withers from Birth to 360 Days of Age Compared with Eckles Normal

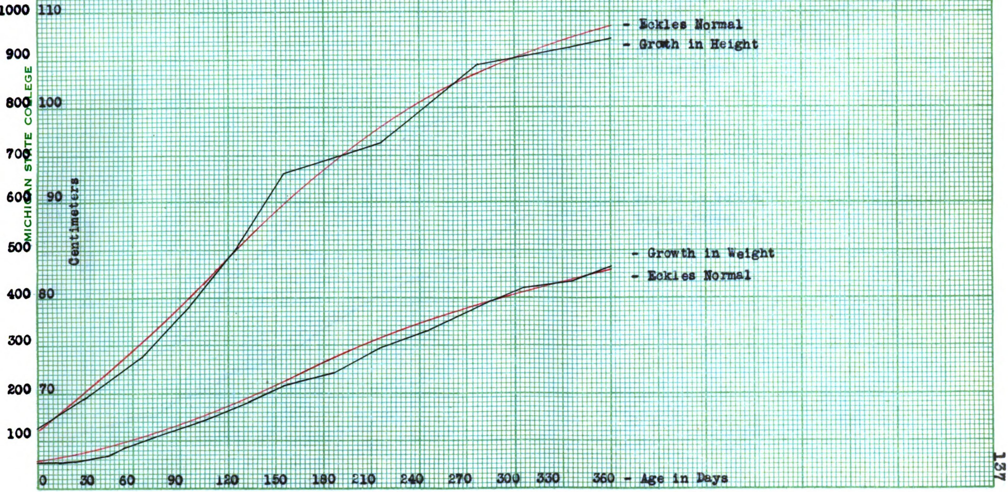
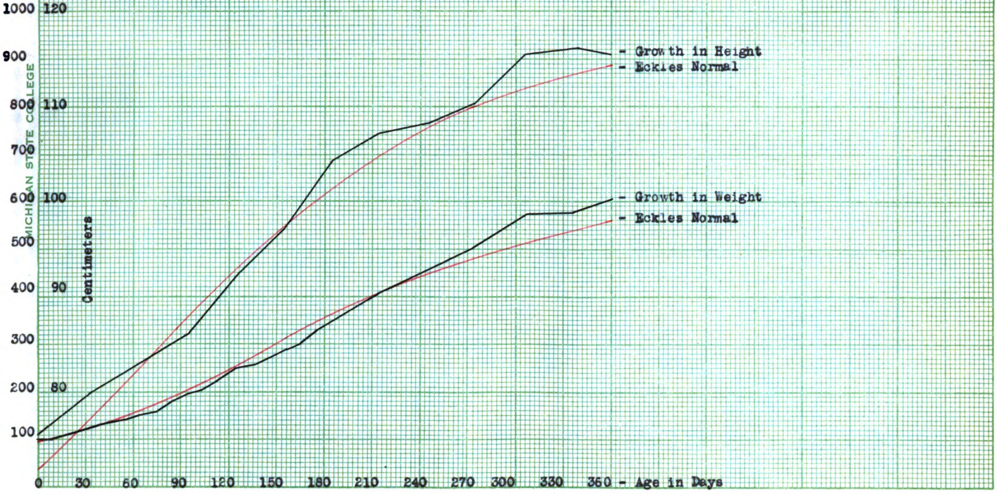


CHART NO. XIII

Animal No. 159 Lot III Fed According to the M. S. C. System. Showing Growth in Weight and Height at Withers from Birth to 360 Days of Age Compared With Eckles Normal



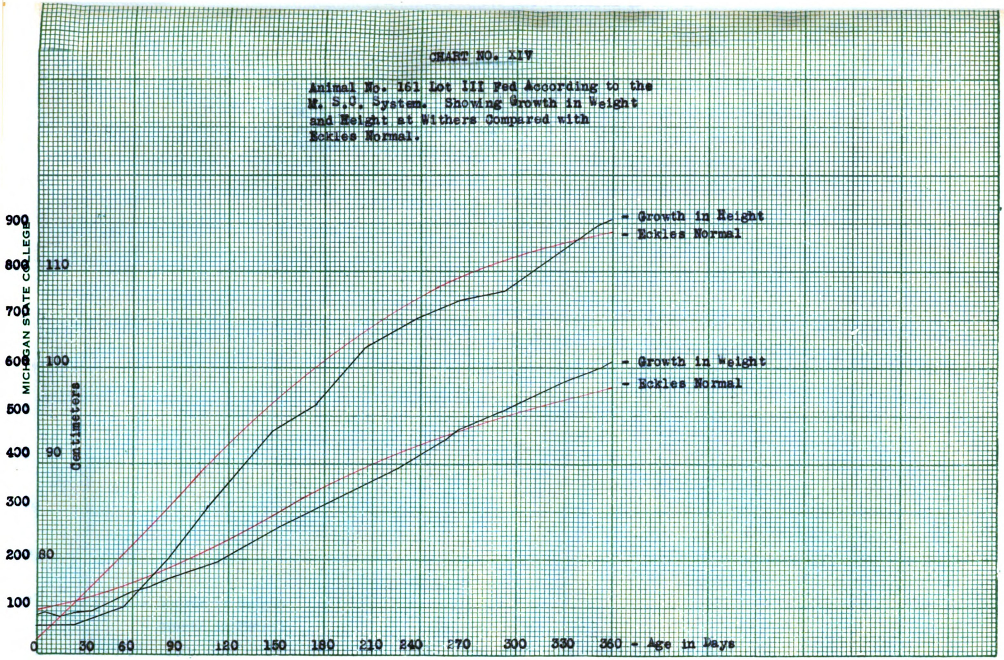


CHART NO. XIV
Animal No. 161 Lot III Fed According to the M. S.C. System. Showing Growth in Weight and Height at Withers Compared with Eckles Normal.
- Growth in Height
- Eckles Normal
- Growth in Weight
- Eckles Normal
Centimeters
80
90
100
110
100
200
300
400
500
600
700
800
900
0
30
60
90
120
150
180
210
240
270
300
330
360 - Age in Days
DEPARTMENT OF MATHEMAT
MICHIGAN STATE COLLEGE

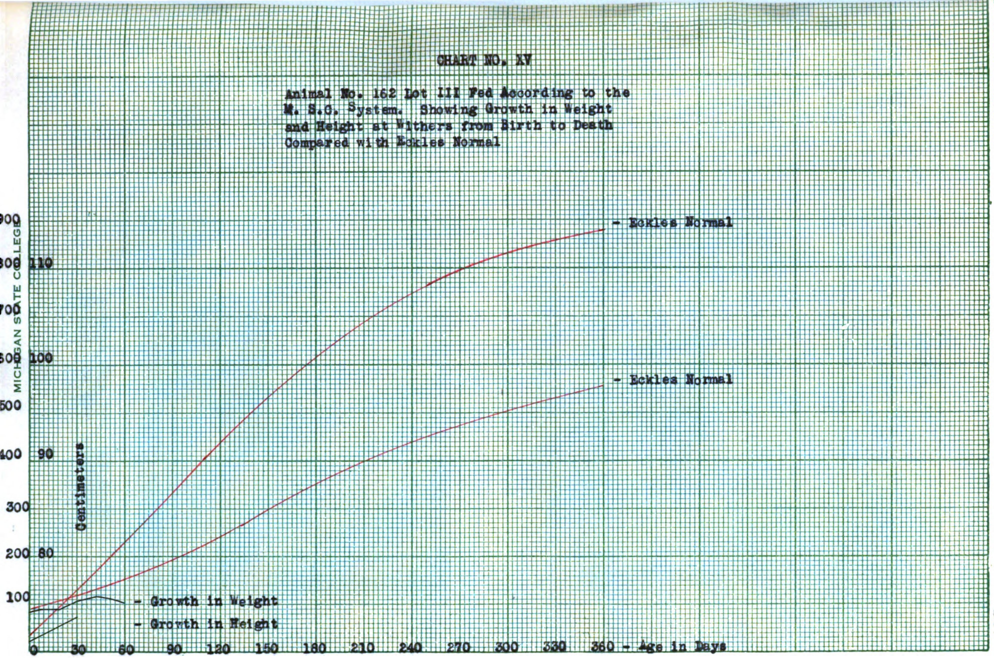
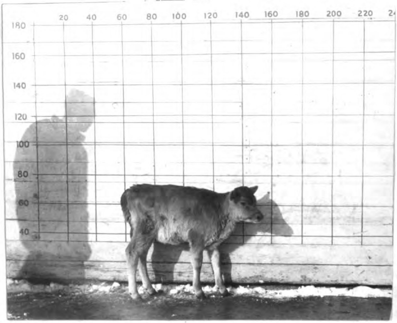



CHART NO. XV

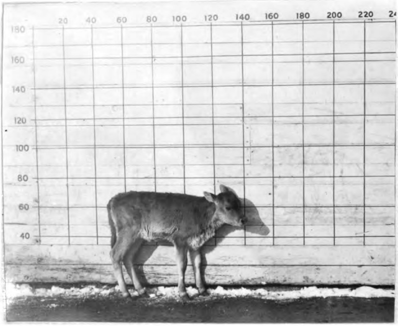
Animal No. 162 Lot III Fed According to the M. S.C. System. Showing Growth in Weight and Height at Withers from Birth to Death Compared with Eckles Normal

PLATE I



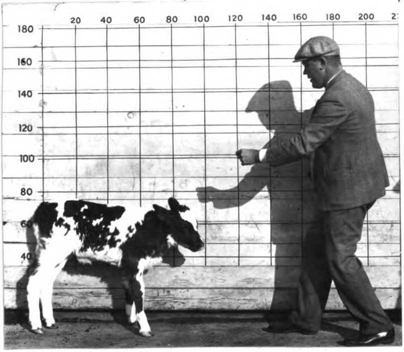

**Animal No. 87. At Birth**
**Lot I, or The Check Lot**

PLATE II



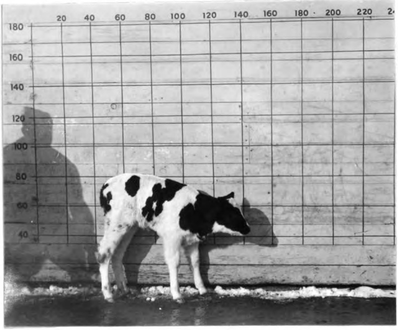

**Animal No. 88. At Birth**
**Lot I, or The Check Lot**

PLATE III



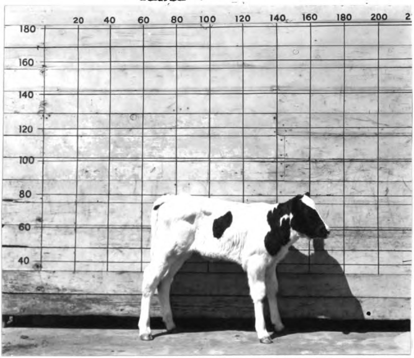

Animal No. 131. At Birth
Lot I, or The Check Lot

PLATE IV



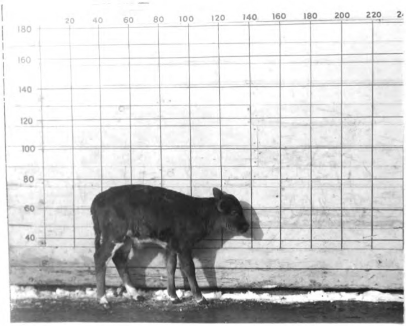

Animal No. 160. At Birth
Lot I, or The Check Lot

PLATE V



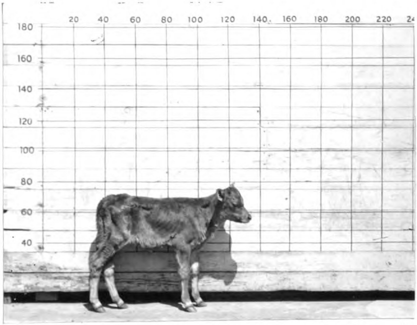

**Animal No. 181. At Birth**
**Lot I, or The Check Lot**

PLATE VI



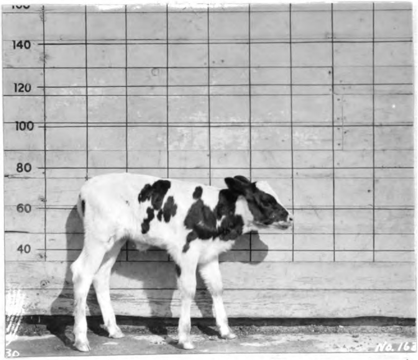

**Animal No. 9's Bull. At Birth.**
**Lot II Fed According to the**
**New Jersey System.**

PLATE VII



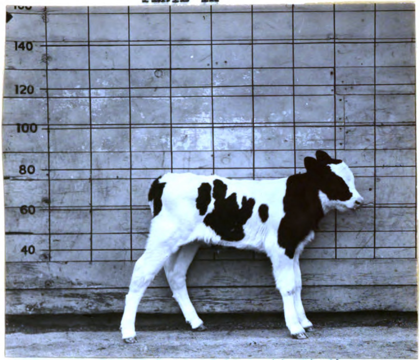

Animal No. 90. At Birth.
Lot II Fed According to
the New Jersey System.

PLATE VIII



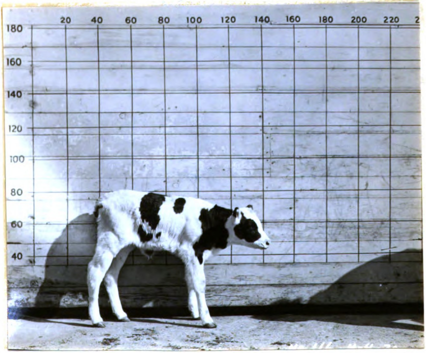

Animal No. 163. At Birth.
Lot II Fed According to
the New Jersey System.

PLATE IX



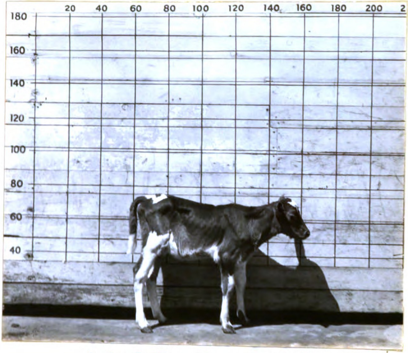

Animal No. 164. At Birth.
Lot II Fed According to
the New Jersey System.

PLATE X




Animal No. 166. At Birth.
Lot II Fed According to
the New Jersey System.

PLATE XI

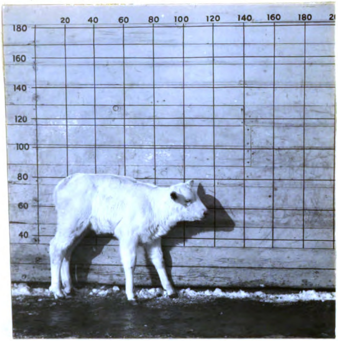



Animal No. 24. At Birth.
Lot III Fed According to
the M. S. C. System.

PLATE XII

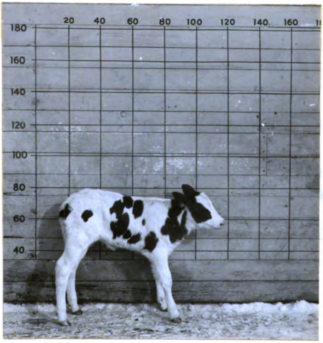

Animal No. 89. At Birth.
Lot III Fed According to
the M. S. C. System.

PLATE XIII



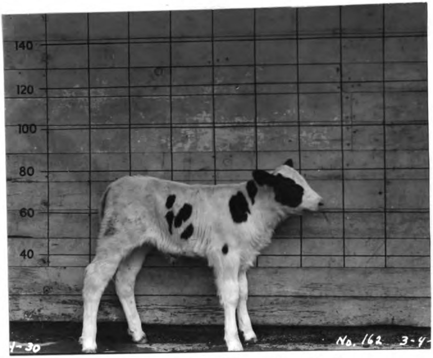

Animal No. 159. At Birth.
Lot III Fed According to
the M. S. C. System.

PLATE XIV



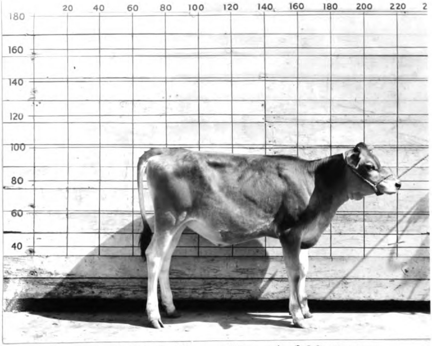

Animal No. 161. At Birth.
Lot III Fed According to
the M. S. C. System.

PLATE XV



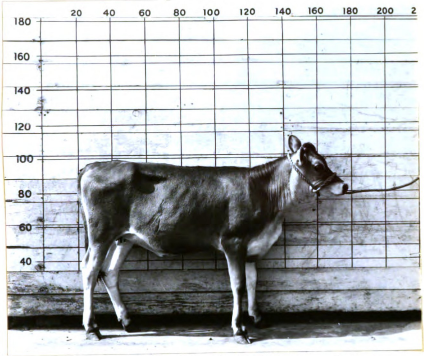
Animal No. 162. At Birth.
Lot III Fed According to
the M. S. C. System.

PLATE XVI



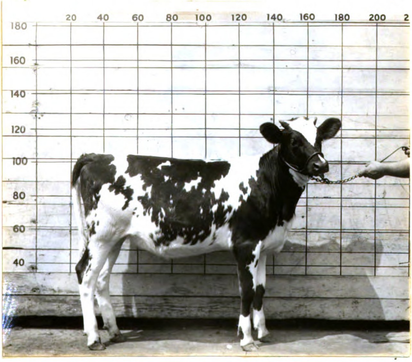
Animal No. 87. At 180 Days
of Age
Lot I, or The Check Lot.

PLATE XVII



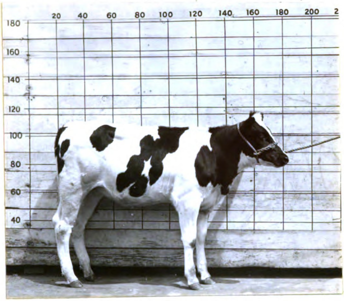

**Animal No. 88 at 180 Days of Age.
Lot I, or The Check Lot.**

PLATE XVIII



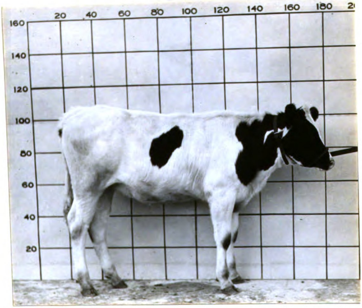

**Animal No. 131 at 180 Days of Age
Lot I, or The Check Lot.**

PLATE XIX



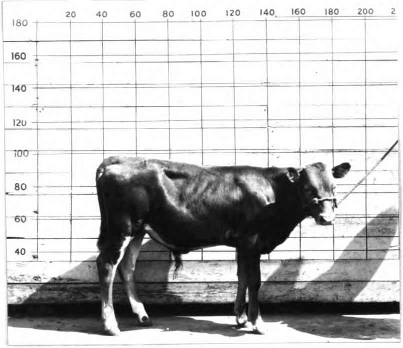

**Animal No. 160 at 180 Days of Age.
Lot I, or the Check Lot.**

PLATE XX



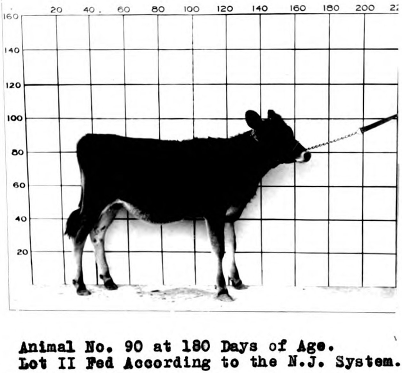

**Animal No. 181 at 180 Days of Age.
Lot I, or the Check Lot.**

PLATE XXI



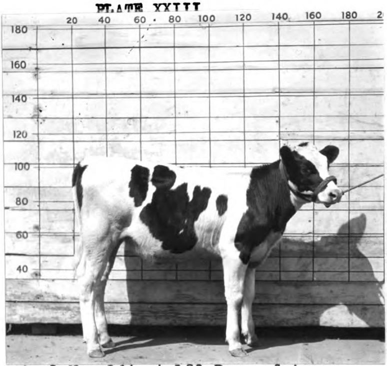

**Animal No. 9's Bull at 180 Days of Age**
**Lot II Fed According to the N. J. System.**

PLATE XXII



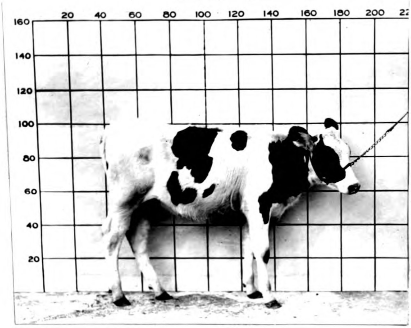

**Animal No. 90 at 180 Days of Age.**
**Lot II Fed According to the N.J. System.**

PLATE XXIII



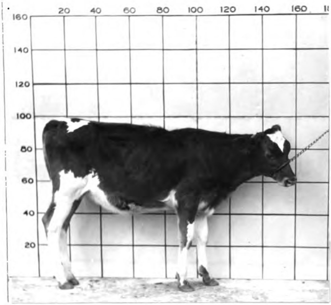

Animal No. 164 at 180 Days of Age.
Lot II Fed According to the N. J. System.

PLATE XXIV



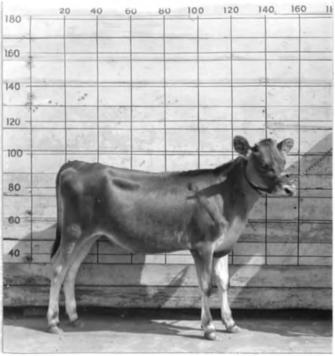

Animal No. 166 at 180 Days of Age.
Lot II Fed According to the N. J. System.

PLATE XXV



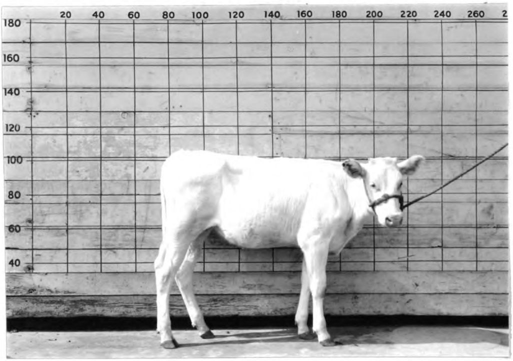

Animal No. 24 at 180 Days of Age
Lot III Fed According to the
M. S. C. System.

PLATE XXVI



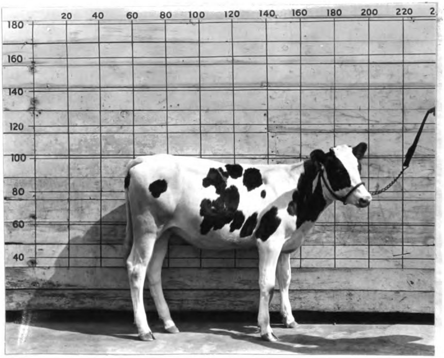

Animal No. 89 at 180 Days of Age.
Lot III Fed According to the
M. S. C. System.

PLATE XXVII



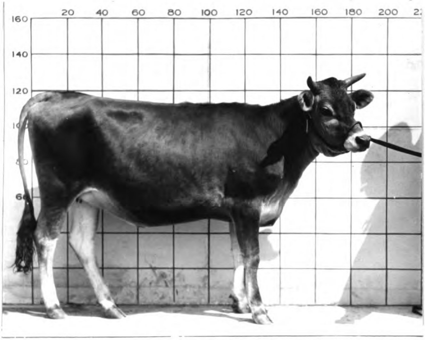

Animal No. 159 at 180 Days of Age
Lot III Fed According to the
M. S. C. System.

PLATE XXVIII



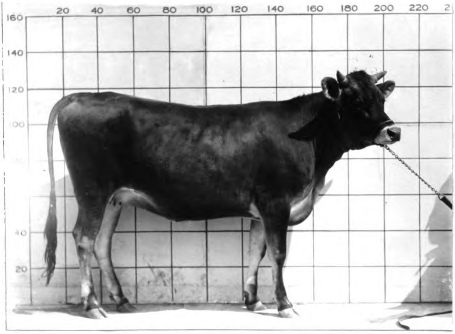

Animal No. 161 at 180 Days of Age
Lot III Fed According to the
M. S. C. System.

PLATE XXIX




Animal No. 87 at 511 Days of Age
Lot I, or Check Lot.

PLATE XXX

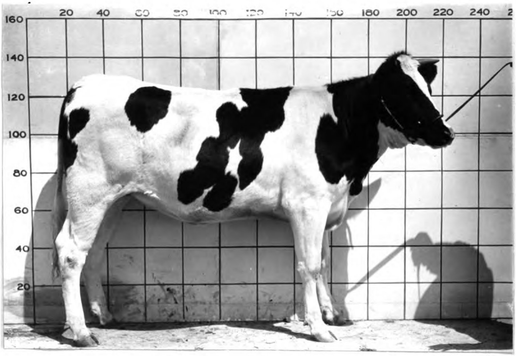



Animal No. 88 at 488 Days of Age
Lot I, or Check Lot.

PLATE XXXI

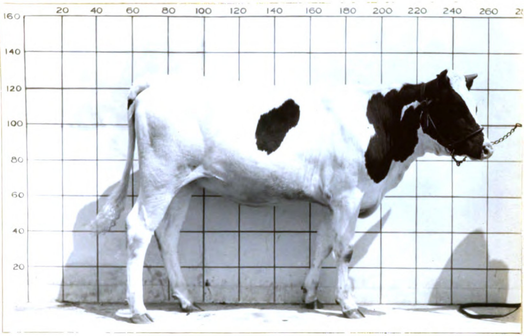

Animal No. 131 at 523 Days of Age.
Lot I, or Check Lot.

PLATE XXXII



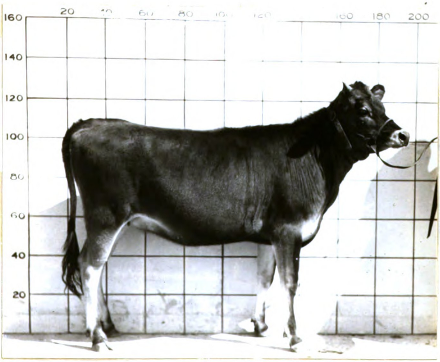

Animal No. 160 at 480 Days of Age
Lot I, or Check Lot

PLATE XXXIII



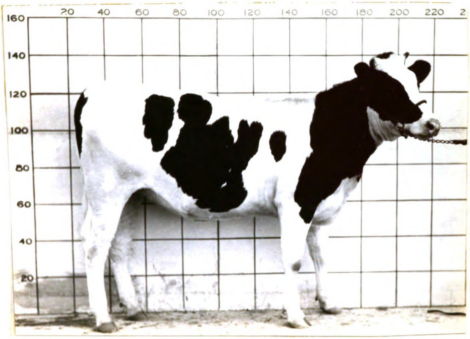

Animal No. 181 at 384 days of Age.
Lot I, or Check Lot.

PLATE XXXIV



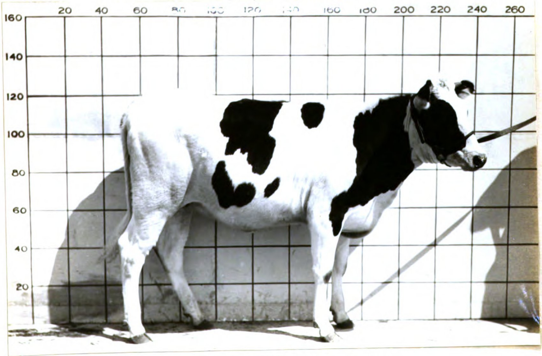

Animal No. 90 at 393 Days of Age.
Lot II Fed According to N.J. System.

PLATE XXXV



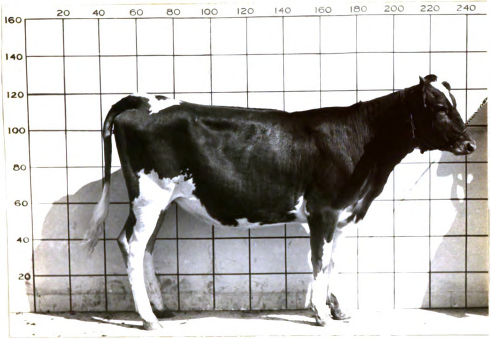

Animal No. 164 at 421 Days of Age
Lot II Fed According to the N.J.System.

PLATE XXXVI



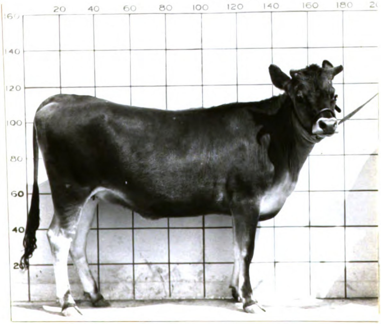

Animal No. 166 at 392 Days of Age.
Lot II Fed According to N.J. System.

PLATE XXXVII



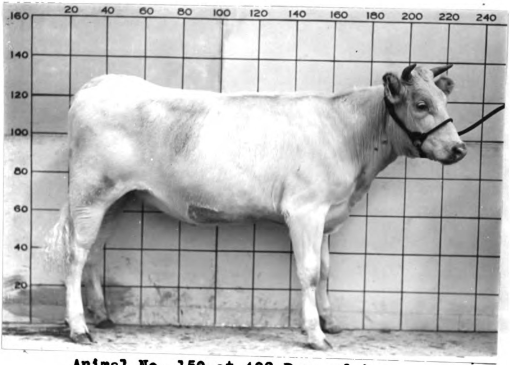

Animal No. 24 at 387 Days of Age.
Lot III Fed According to the
M. S. C. System.

PLATE XXXVIII



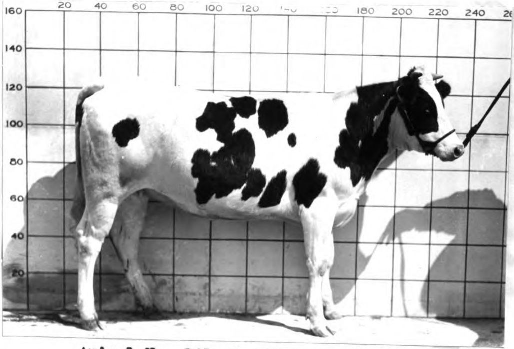

Animal No. 89 at 460 Days of Age.
Lot III Fed According to the
M. S. C. System.

PLATE XXXIX




Animal No. 159 at 490 Days of Age.
Lot III Fed According to the M. S. C.
System

PLATE XL




Animal No. 161 at 450 Days of Age.
Lot III Fed According to the M. S. C.
System.