Philip Martin Brandt.
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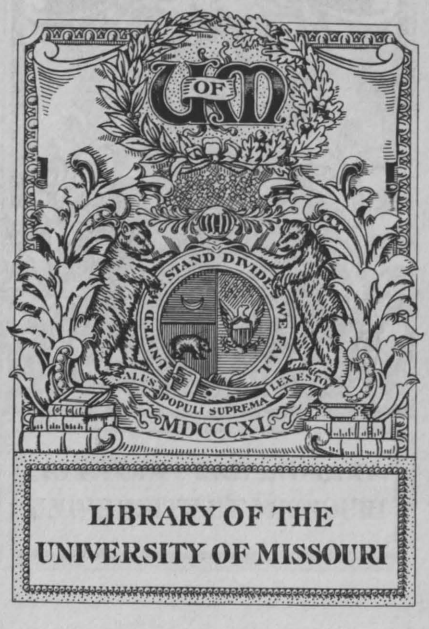

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THE NUTRIENTS REQUIRED FOR GROWTH BY HEIFERS OF DAIRY BREEDS

by

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INTRODUCTION.

According to the census figures there are approximately 20,000,000 cows used for dairy purposes in the United States at the present time. It is probably safe to assume that these cows are milked on the average not more than five years and that they have to be replaced when they are not more than seven years old. This means that practically 4,000,000 cows must be raised each year in order to keep up this number. Since the heifers do not come into milk until they are two years of age it is necessary at any one time to have approximately 8,000,000 heifers in the herds that are being raised to replace the cows then in use for milking purposes. According to data that has been gathered by experiment stations it apparently costs from $50.00 to $60.00 in the way of feed to raise a heifer to the age where she commences to return a profit in milk. These statements indicate the size and importance of the ques-

tion of the proper feeding of dairy animals from birth to the time they come in milk.

The larger number of these heifers are fed during the first six months of their lives on skim milk. This period of feeding has been made the subject of extended investigations and at the present time both investigators and practical men agree in regard to the best practice for feeding during the milk feeding period.

Very little has been done in the way of experimental work to determine the best methods of feeding and developing dairy heifers from the time of weaning to the time they come in milk. The experience and observations of practical men is at the best our only guide. Furthermore, another important question arises in this connection and that is to what extent is the dairy capacity of a mature cow influenced by the manner of feeding during the first two years of her life. This question is of special importance in view of the fact that the experience and observations of the farmers as well as of experiment station men has been that at least one out of every four heifers raised proves to be unprofitable. The question then of proper raising of dairy heifers involves not only an immense expense for feed but also this important question of the influence of the methods of feeding upon the later

value of the animal.

An extensive investigation was started at the Missouri Experiment Station in 1906 which has for its object the investigation of certain problems in regard to the growing of dairy heifers. The main object in view was to ascertain if the dairy qualities of the cow are influenced by the manner of feeding when young. This investigation is not as yet completed and the data has not been put in printed form. This data has not been taken with the special intention of studying the question of nutrients required for growth but it is possible to use it for this purpose. The purpose of this thesis is to study a portion of the data on hand that has been taken in connection with the experiment mentioned with the view of ascertaining the nutrients that were required for growth by the animals used.

It will be noted in the description of the manner of feeding given later that the animals used in supplying the data made the basis of this thesis were in two groups. One of these groups received a ration containing more nutrients than is the common practice to feed animals at this age. Those in the other group received a ration somewhat lighter than that ordinarily fed. In other words neither group exactly represents what is probably the best

practice of feeding. The conditions, however, are not very extreme and it is believed that the data has a value, and that it can be applied to animals in ordinary herds with no serious error.

LITERATURE.

A study of the literature on this subject reveals the fact that there is little definite information to be had. The standard texts give general discussions of the greater requirements of certain general classes of nutrients --protein and ash--by very young animals as compared to older animals. No one has attempted to describe very much in detail the rate at which young cattle should be expected to grow. There is but one instance of where a suggestion is made as to what weight animals should reach at certain ages. It is obvious that with such meager references any work of this nature is made difficult and unsatisfactory, and that little more can be done than present the data as secured.

Kellner[1] states that, "Every constituent of the food which can yield heat or energy, or can serve for the production of body tissue, is called a nutrient." In this

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1.Kellner, "Die Ernahrung der Landwirtschaftliche Nutztiere"; English translation by Goodwin". "The Scientific Feeding of Animals," page 43.

paper the nutrients discussed will be confined to the "digestible protein" and "energy value" as defined by Armsby[1]. The rations from other experiments have all been recalculated to terms of energy value and digestible protein according to the "Production Value" tables suggested by Armsby[2], and those described later in this paper. When the nutrients required for a pound of growth are mentioned it should be understood that they include the maintenance requirements.

Kellner[3] reports a feeding experiment with a 2-3 weeks old suckling calf in which complete record of the income and outgo was made. It was found that the digestion and assimilation of the food was very complete, especially of the protein and mineral constituents. The digested protein was stored in the body to the extent of 72.6 per cent. 53 per cent of the total ash was retained. Of this ash 72.5 per cent of the phosphoric acid was retained and 97 per cent of the lime. An experiment with calves 5-6 months of age showed that only 46 per cent of the phosphoric acid was retained in the body and 42 per cent of the lime.

He also states that the use to which animals are to be put in later life should be considered in feeding them when young.

1.Pa. Exp. Sta. Bul. 71
2.U.S. Dept. Agr. Farmers' Bul. 346.
3.Kellner, "Die Ernahrung der Landwirtschaftliche Nutztiere"; English translation, "The Scientific Feeding of Animals", page 284.

In the feeding of young calves the quantity of milk fed should be determined by their body weight and the purpose for which they are intended. If intended for milk or draught purposes their ration should be lighter than if intended for beef purposes.

Young calves have only a simple stomach and should be fed at first on easily digested food. Later, coarser foods can be given, beginning with small amounts of early cut hay to encourage the formation of the fore stomachs.

Henry[1] quotes an experiment by Jordan at the Maine station in which two groups of steers were fed on different rations, one being high in protein, and the other low in protein. The experiment was carried on until the calves were 27 months of age.

The steers on the high protein ration made much more rapid growth early in life than did those on the low protein ration. At the end of 17 months those on the high protein ration averaged 174 pounds heavier than those on the low protein ration. At the end of 27 months, however, the two animals were at practically the same weight, those animals on the protein poor ration gaining at a more rapid rate later in the feeding period than those on the protein high ration. The animals receiving the greater amount of protein had the best appearance as to thrift and health.

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1. Feeds and Feeding, ninth edition, p. 88

Henry[1] quotes the following experiments. One carried on by Bertschinger, fattening calves on whole milk. A pound of gain was made from 10.1 pounds of whole milk. Assuming that the milk contained 4 per cent fat this amount yields 1.77 therms of energy and .35 pounds digestible protein. The calves were fed eleven weeks and the average is for the whole period.

Between the first and fifth week, calves required 6 pounds of whole milk to produce a pound of gain as found by Martin[2]. This amount of milk if containing 4 per cent fat will yield 1.07 therms energy and .22 pounds protein when calculated according to the method to be described.

Hunt[3] fed 3 calves for 161 days, beginning several days after birth. His trial was to determine the relative values of different grains to be substituted for the fat in whole milk containing 4.6 per cent fat. They were fed hay as they grew older. When the energy value and digestible protein is calculated from the rations given the nutrients required for a pound of growth are found to be 3.02 therms energy and .62 pounds digestible protein. The calves averaged a gain of 1.77 pounds daily during the period.

Henry[4] quotes an experiment by Du Roi in which

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1. Feeds and Feeding, ninth edition, p. 325
2. Loc. Cit. p. 334
3. Pa. Agr. Exp. Sta. Annual Rept. 1891.
4. Loc. Cit. p. 335.

calves were fed a small amount of whole milk, the remainder of the ration being skim milk for 37 days. A pound of gain during this period required approximately 1.89 therms energy and .85 pounds digestible protein.

Curtiss[1] at the Iowa Station reports work with young growing calves to determine the best feed to supplement the fat removed from milk in the skimming process. As that reported in Bulletin 35 is a repetition of the work reported in the others mentioned and is given more in detail, it alone will be discussed here. This experiment was carried on with three lots of calves, each being fed skim milk with some grain and hay. The trials commenced with calves averaging about 190 pounds in weight and lasted 60 days for one lot, 74 for another, and 90 for the other. The animals gained at the average rate of 1.4 pounds per day. They required for a pound of growth 2.74 therms energy and .67 pounds of digestible protein.

Skinner[2] and Cochel working to determine what influence the age has on the economy and profit of fattening steers in winter, used calves, yearlings and two year olds. It appears, however, that the calves averaged more than 400 pounds in weight when they were placed in the experiment. The age is not given.

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1. Ia. Agr. Exp. Sta. Bul. 35
2. Purdue Agr. Exp. Sta. Bul. 136.

The nutrients required for a pound of growth, calculated from data given in Table IV of their work shows the following:-

Nutrients Required for a Pound of Growth

(Including maintenance)

	Initial Weight Lbs.	Energy Therms	Digestible Protein Pounds
Calves	474	6.16	.78
Yearlings	684	7.52	.96
2 yr. olds	966	9.30	1.19

This data is of no particular value in this discussion except as evidence that the use to which an animal is to be put not only influences the method of handling but the use of the terms describing it. When speaking of dairy animals one would hardly call a 474 pound animal, a calf.

Norton[1] gives the record of the feed required to grow a large number of heifers. They were divided into groups and the total feed records kept of the groups. Three of these groups, Lots IV, V and VI that were made up of high grade and pure bred dairy cattle are herein

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1. Michigan Agr. Exp. Sta. Bul. 257.

reported. The animals were mostly Holsteins, the others being Shorthorns, Guernseys, and Jerseys. The feed and weight record is kept from birth. They were fed on whole milk, skim milk, grain, dried beet pulp, roots, hay and green corn. The nutrients of the total ration for 12 months is calculated in energy value and pounds digestible protein from the data presented in the bulletin. The animals gained weight at the rate of 1.57 pounds daily during the first year of their life. It required 2.93 therms energy and .54 pounds digestible protein to produce this daily gain.

Trueman[1] reports the total feed required by five heifers up to two years of age. Two of these were Jerseys, one a Guernsey and two Holsteins. The animals were on pasture part of the time. This makes it possible to calculate the total nutrients received for certain periods only during the time the records were kept. As in the data to be presented later, the two years were divided into periods of six months each. The nutrients received and the growth made during these six months have been calculated. Where the feed record is given for a fraction of the six months in any period the calculation is made for those months only but counted as the average for the period. The data is here given for the first and third six months periods.

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1. Storrs Agr. Exp. Sta. Bul. 63.

During the second and fourth periods the animals were kept on pasture. The results of the calculation are interesting even with the records incomplete.

The Guernsey and Jerseys being near the same size are included in one group, while the two Holsteins are included in a second group. The average gain in weight by the Jerseys and Guernseys for the first six month period was 1.15 pounds per day. That of the Holsteins was 1.64 pounds. The average gain per day by the Jerseys and Guernseys for the third period was .84 pounds while by the Holsteins it was .95 pounds.

During the first six month period the Jerseys and Guernseys required 2.20 therms energy and .59 pounds digestible protein for a pound of growth while the Holsteins required 1.52 therms energy and .33 pounds digestible protein for one pound of growth.

During the third period the Jerseys and Guernseys required 5.95 therms energy and .96 pounds digestible protein for a pound of growth, while the Holsteins required 5.76 therms energy and .87 pounds digestible protein for a pound of growth.

A careful consideration of the literature indicates clearly that as the animals grow older a pound of growth including maintenance requires more nutrients. This of course is a fact generally recognized.

EXPERIMENTAL WORK

As indicated in the introduction the work reported in this paper is the result of a study of a portion of the data taken in an experiment now being carried on at this Experiment Station entitled, "A study of certain factors regarding the development of dairy cattle."

The factors studied in this paper are mainly;-

1. The effect of the supply of nutrients on the rate of growth.

2. The difference if any in the rate of growth by the different breeds.

3. The nutrients required for a pound of growth when animals are fed on a heavy as compared to a light ration.

4. The effect of age and breed on the rate of growth and the nutrients required for a pound of growth.

Discussion of the Data.

In the experiment to which reference is made, the animals were divided into two general groups. The first group included 9 animals which were fed a heavy ration from birth to first calving. The second included

8 fed a light ration from birth to first calving. For convenience in the discussion these groups will hereafter be designated as the "heavy fed group" and the "light fed group".

Selection of Animals -- All animals were pure breds from the Missouri Experiment Station herd and were of the Jersey, Holstein, and Ayrshire breeds. They were assigned to their respective groups as soon after birth as it appeared they were normal as to health and strength. The individuals in the different groups were balanced against each other with respect to breeding in so far as it was possible to judge this breeding.

Stabling -- The animals were kept in the barn at night and one very cold days in the winter. On pleasant days they were turned out in a dry lot. In summer they were brought in the barn only at feeding time, at all other times being kept in a dry lot. When in the barn they were tied in stanchions.

Feeding -- The calves were taken from their mothers at the average age of 5 or 6 days. If one was taken from its mother at an earlier age, it was fed its mothers milk for that length of time. The light fed calves received whole milk from the herd until they were two weeks of age when they were gradually changed to skim

milk. The heavy fed calves, after they ceases to receive their mothers' milk were fed on whole milk from the herd until weaned. The milk fed both groups was fed as near a temperature of 90°F. as possible and care was taken that the vessels used in feeding were perfectly clean. The animals in both groups were weaned at the age of six months.

The grain fed thruout the whole experiment was a uniform mixture of 2 parts corn, and 1 part oats. No grain was fed the calves in the light fed group. Those in the heavy fed group commenced to receive small quantities of grain at an average age of about four weeks. The amount consumed at this age was small. Care was exercised in feeding grain when the calves were very young. Later when they became accustomed to the grain and their digestive organs were more strongly developed they were given all they would eat up clean.

The animals in both groups were given all of the hay they would eat up clean at all times. Alfalfa hay was generally fed, altho at times when not available other leguminous hay was fed. The animals discussed in this paper were not placed on pasture until after they calved. During the summer months green alfalfa hay was fed. At times when no green alfalfa was available green corn was substituted. Salt was available at all times.

Feed Records -- As soon as the animals were old enough to receive milk from the pail the amount given each at a feed was weighed on a scale provided for that purpose, and the weight recorded. A composite weekly sample was taken of both the whole milk and skim milk. These samples were taken to the Dairy Building at the end of each week and tested; the whole milk for the per cent of butterfat by the Babcock method and for specific gravity with the Westfall Balance, and the skim milk for specific gravity by the same method. The results of these tests were recorded in the feed record books and used in calculating the fat and the solids not fat of the milk.

The grain was mixed in the feed room in large quantities. A bucket was provided for each animal and a certain amount of feed weighed into it, the same being recorded on the proper sheet in the feed room. The animals were given what they would eat up clean each day from the large bucket which was refilled from time to time. If any animal refused a part of the grain fed, the refuse was weighed and deducted from the record of the amount fed.

Hay was fed to the heavy fed animals once a day, generally in the evening, and to the light fed animals twice a day. Each animal received all she would eat up

clean, the amount fed being weighed. As with the grain, if an animal refused part of the hay, that amount was weighed and deducted from the total fed.

A record of the amount of green feed in the summer was kept essentially the same as for the hay and grain. All barn record sheets were removed to the Dairy Building at the end of each month where the records were added up and put in the permanent record books.

Weighing -- The birth weight of each animal was taken and thereafter each animal was weighed the 15th of month. The weights were taken in the morning, generally between 8 or 9 o'clock, before receiving water. From the beginning of the experiment until May 1908, the animals were weighed only one day in each month. Beginning in May 1908 the animals were weighed three consecutive days in the middle of the month, generally the 14th, 15th, and 16th, and the average of these three weighings taken as the average weight for that month. This change in the method of weighing was made because of the unavoidable fluctuation in the weights when taken only once each month. This will be referred to later.

Animals Used -- As mentioned before the animals from which the data is taken that is used here were kept on dry feed until their first calving. In this way the

feed records are complete for the time included. Table I shows the herd number, breed, date of birth, and the group of the individual animals used. The numbers of the Jerseys are all under 100, those of the Holsteins between 100 and 200, and those of the Ayrshires over 300. It is unfortunate that No. 307 was not kept off pasture as was planned. Her complete feed record covers only the first six months of her life.

Calculating the Nutritive Value of the Feed:--- With the exceptions noted all calculations of nutrients in this paper are made according to the"Production Value" suggested by Armsby[1] As his tables giving the energy value and digestible protein of the common feed stuffs do not include milk solids, it was necessary to first calculate the energy value of a pound of milk solids not fat. The solids not fat of the skim milk were presumed to contain fat at the rate of .1 per cent of the milk. Milk solids were found by Eckles and Shaw[2] to contain an average of 27 per cent protein, 37 per cent sugar and 5.3 percent ash. When .1 per cent butterfat in milk is calculated to terms of total milk solids, it

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1. U. S. Dept. Agr. Farmers' Bul. 346
2. U. S. Dept. Agr. Bureau of Animal Ind. Bul. 155, pps 54-55.

TABLE I

Description of Animals

No. of Cow	Date of Birth	Breed	Treatment
3	12/16/07	Jersey	Light Fed
11	7/17/08	Jersey	Light Fed
14	1/11/09	Jersey	Light Fed
39	6/12/07	Jersey	Light Fed
215	1/ 1/07	Holstein	Light Fed
219	1/31/08	Holstein	Light Fed
222	8/12/08	Holstein	Light Fed
224	2/ 1/09	Holstein	Light Fed
307	12/21/08	Ayrshire	Light Fed
2	5/ 1/08	Jersey	Heavy Fed
8	1/ 2/08	Jersey	Heavy Fed
13	10/12/08	Jersey	Heavy Fed
216	7/17/07	Holstein	Heavy Fed
220	2/ 6/08	Holstein	Heavy Fed
223	8/27/08	Holstein	Heavy Fed
225	8/14/09	Holstein	Heavy Fed
306	12/ 9/08	Ayrshire	Heavy Fed

amounts to 1.14 per cent of the total solids. The above constituents represent the total solids in the skim milk fed and are 70.44 per cent of the total solids of milk. The percentage composition of the skim milk solids was calculated from the above data and estimated to be as follows;-

Protein	- 38.33 per cent
Sugar	- 52.52 per cent
Fat	- 1.62 per cent

The ash yielding no energy will not be considered. The energy value of the total solids was found to be .858 therms per pound. The energy values of protein, sugar and fat given by Armsby[1] were used in this calculation. Milk sugar for this purpose is considered to have the same energy value as cane sugar. As protein in milk solids is practically all digestible the amount of digestible protein in a pound of milk solids was considered .3833 pounds.

The production value of the other feeds in terms of energy and the pounds digestible protein are all found in Armsby's[1] tables. The energy value and protein content of a pound of solids not fat in the whole milk fed was considered the same as a pound of the total solids in the skim-milk.

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1. Pa. Agr. Exp. Sta. Bul. 71, p. 14
2. U. S. Dept. Agr. Farmers' Bul. 346.

Deducting Maintenance from the nutrients fed -- It would seen that the logical way of getting at the nutrients required for growth would be to deduct the maintenance requirement of the animal from the total nutrients fed. Armsby[1] suggests daily maintenance requirements for cattle at different weights. So far as could be determined by studying the literature, this is the only definite suggestion as to the maintenance requiremens of growing animals. He found the requirements given in these standards by calculations from his results in determining maintenance requirements for mature steers.

In applying these requirements, for convenience, a working table was calculated from the original so as to give the maintenance requirements of animals for each 25 pounds increase in weight beginning with 75 pounds. The maintenance requirement for any animal was found by referring to the table and finding the requirement for the animal nearest its weight.

This method of course is not absolutely aorrect. The maintenance requirement of a growing animal is probably not the same any two days in succession while this method used the same requirements for periods of one month because the average weight of the animals was for that time.

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1. U. S. Dept. Agr. Farmers' Bul. 346.

Again, the requirements are not figured exactly to the weight of the animal. Considering these factors, however, any comparisons made on this basis would probablybe accurate enough to come within the limits of experimental error.

Table II gives the average nutrients left for growth each day after the daily maintenance requirements as calculated from Armsby's tables have been deducted. The table covers a period of six months. In the last month only did this animal receive as much energy as she was supposed to require for maintenance. Yet she has made an average daily gain of 1.43 pounds for the six months. The maintenance requirement of eight animals calculated from Armsby's tables was deducted from the nutrients received by them and while they did not all show such a large deficiency as did No. 215, there was a decided shortage in energy. All of them at least during one month of the first six months did not receive as much energy as they were supposed to require for maintenance and all made good gains.

All eight animals reported were in the light fed group. The heavy fed group received more energy at all times than they were supposed to require for maintenance but not enough to produce the gain they actually made. After the first six months all those in the light fed group received more energy than they were supposed to require for

TABLE II

Nutrients for growth per diem after deduction of maintenance requirements.

No. 215

Months	Energy Therms	Digestible Protein Pounds	Average daily gain Weight
June	-.19*	.37	
July	-.35	.51	1.29
August	-.47	.58	1.52
Sept	-.58	.59	1.42
Oct.	-.09	.74	1.47
Nov.	.23	.80	1.45

* - indicates a deficiency.

maintenance. The estimated protein requirement for maintenance, however, was always less than the protein fed.

In considering these results it should be recalled that Armsby calculated the maintenance requirements for growing cattle from the maintenance requirements of mature steers. Furthermore, it has already been brought out in the discussion of the literature and is a well established fact that young animals assimilate their food more completely than do older animals. Eckles[1] has shown that the production values as given by Armsby[2] for milk production are too low. Cows frequently will produce more energy in milk than they are receiving for the production of milk. It would seem, therefore, that further investigations on the utilization of energy by growing animals as well as by cows in milk must be carried out, it being clear that the production values on mature steers do not apply to these classes of animals.

The results shown in Table II made it necessary to adopt some other plan of presenting the data wherein the maintenance requirements would be dealt with in a different manner. It was thought best to include the maintenance requirement with the nutrients used for growth. Hereafter it shall be understood that in this discussion the "Nutrients required for growth" will include the maintenance requirements.

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1. Mo. Agr. Exp. Sta. -- unpublished data.
2. U. S. Dept. Agr. Farmers' Bul. 346.

The periods -- The arrangement of the data is made in periods of six months. These are numbered consecutively beginning with the birth of the animal. The first period frequently contains a fraction more than six months when the animal was put in the experiment before the first of the month. Other periods are made up of less than six months at times when there was a break in the data or the animal calved before the end of the period. In calculating the per diem data for all periods, the actual number of days in a period was used and the result called the average for that period.

The six month periods end with the last day of a month in all cases. The animals were all weighed the middle of the month. This made it necessary in calculating the live weight for any one period to calculate the weight at the end of the month from the weights taken in the middle of the month ending the one period and the one beginning the next. This was taken to represent the weight of the animal at the end of the period and was considered the weight at the beginning of the following period.

Variations in Weight -- At this time it is well to explain the difficulty encountered in getting accurate records of the live weights. As explained before, it was deemed advisable after the experiment had been in progress some time, to weigh the cows three days in succession in the

middle of the month and to use the average of these three days for the average weight of the month. This precaution, however, did not prevent unlooked for and unaccountable variations in weight from month to month. Table III gives a fair example of such variations and showe where the animal apparently lost weight in two different months. This is typical of almost every animal in the experiment. Some of the losses are not so great as those shown in Table III while others show an average loss of over one pound per diem for some months. A careful study of the gain per diem of several of these animals reveals the fact that there is an unusual rate of gain during some months previous to the months showing losses, while in other cases a loss is shown with no apparent high rate of gain on the month previous to or following it.

It is also observed that as the animals grow older this variation in weight is more frequent. It is not uncommon to find a variation of 75 to 100 pounds from day to day in the weight of cows giving milk. Just what this fluctuation in weights is caused by is not clear. Part of it is probably due to the difference in the amount of fill carried from day to day. Mr. W. M. Regan[1] has suggested that the differences in temperature and humidity may cause animals to drink more on certain days than on others and

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TABLE III

Unaccountable fluectuation in weight.

No. 39

Month	Weight	Average gain per diem
January*	270	1.45
February	260	-.32**
March	290	1.03
April	310	.65
May	305	-.17
June	338	1.06
July	348	.33
August	379	1.00

* 7th month

** - indicates daily loss of weight

that these conditions might influence the rate of evaporation from the surface of the animal and in this way cause a fluctuation in weight. At present this is a question open for investigation.

But one would hardly expect such a great variation as found in the weights of the growing animals altho some variation would be expected. The barn records were consulted in making these observations and the losses in weight are not due to the animals being "off feed". This question is brought up at this time because it happens that several of the six month periods end at times when there is an apparent loss in weight. In some cases this loss was great enough to cause a material decrease in the rate of gain for the period ending then and to cause a material increase in the rate of gain or the total gain in the period commencing with that month. The rate of gain affects the nutrients required for a pound of growth and in several of the periods wherein unusually high requirements for a pound of growth are noted they are undoubtedly caused by this fluctuation in the rate of gain.

Feed Received -- Tables IV, V, VI, VII, VIII, IX, X, XI, and XII give the feed received by the individuals in the different periods. The fat and solids not fat represent the nutrients of the milk. The solids not fat

TABLE IV

Feed Received Up to First Calving. Arranged For Periods of Consecutive Six Months.

Period	Fat	Solids not Fat	Hay	Green Feed
No. 3		**Light Fed Group**		
1	7.9	275.7	345.0	61.0
2			869.6 (c) 309.0 (d) 462.0	707.3 (l) 490.0
3			1192.8 (d) 437.2	557.0
4			1801.5	539.0
Total	7.9	275.7	5417.1	2354.3
No. 11				
1		224.2	425.0	
2			1334.0	1282.0
3			1985.3 (a) 474.0 (d) 155.3	100.0
4			1929.0 (a) 333.0 (b) 604.0	
Total		224.2	7239.3	1382.0

(a) Alfalfa and clover
(b) Alfalfa and cowpeas
(c) Clover
(d) Cowpeas
(l) Green corn

TABLE V

Feed Received Up to First Calving. Arranged For Periods of Consecutive Six Months.

Period	Fat	Solids not Fat	Hay	Green Feed
No. 14		**Light Fed Group**		
1	6.3	267.6	542.0	115.0
2			1463.6	71.0
			(a) 383.1	
			(d) 108.6	
3			1869.0	
			(a) 250.2	
			(b) 588.8	
4			2201.3	
			(d) 150.9	
			(c) 633.1	
5			3330.0	
Total	6.3	267.6	11519.9	186.0
No. 39				
1		288.5	264.5	
2		37.8	1137.5	329.0
				(1)6449.0
3			1774.5	(1)2142.1
4			1741.5	
Total		326.3	4918.0	3116.0

(A) Alfalfa and clover
(b) Alfalfa and Cowpeas
(c) Clover
(d) Cowpeas
(1) Green corn

TABLE VI

Feed Received Up to First Calving. Arranged

For Periods of Consecutive Six Months.

Period	Fat	Solids not Fat	Hay	Green Feed
No. 215		**Light Fed Group**		
1		344.0	198.0	
2		47.9	1829.9	335.0
3			1913.0	(1) 2775.6
4			3041.0	
			(a) 698.0	
5			2669.0	
			(a) 1309.0	
Total		391.9	11657.9	3110.6
No. 219				
1	5.8	269.6	448.5	
		4.1	810.4	(1) 510.3
2			(d) 864.2	
			(c) 31.8	
3			1778.8	1527.0
			(d) 73.2	
4			2784.0	
4			(a) 748.0	131.0
			(d) 111.5	
			2710.5	
5			(a) 841.0	
			(b) 62.8	
6			2972.2	
			(c) 514.5	
Total	5.8	273.7	14751.4	2168.3

(a) Alfalfa and Clover
(b) Alfalfa and Cowpeas
(c) Clover
(d) Cowpeas
(1) Green corn

TABLE VII

Feed Received Up to First Calving. Arranged For Periods of Consecutive Six Months.

Period	Fat	Solids not Fat	Hay	Green Feed
No. 224		**Light Fed Group**		
1	78.8	227.0	537.5	
2			1366.1	
			(a) 42.0	
			(d) 116.0	
3			1735.8	
			(a) 273.6	
			(b) 547.6	
4			3424.5	
5			529.0	
Total	78.8	227.0	8572.1	
No. 307				
1	3.3	279.4	545.5	

(a) Alfalfa and clover
(b) Alfalfa and cowpeas
(c) Clover
(d) Cowpeas

TABLE VIII

Feed Received Up to First Calving. Arranged For Periods of Consecutive Six Months.

No. 222 — Light Fed Group

Period	Fat	Solids not Fat	Hay	Green Feed
1		244.5	674.9	
2			1616.2	1414.5
3			1926.8	
			(a) 889.3	
			(d) 169.4	
4			3093.2	
			(b) 541.8	
5			2651.8	
			(d) 194.5	
			(c) 775.3	
6			1313.0	
Total		244.5	13846.2	1414.5

(a) Alfalfa and clover
(b) Alfalfa and cowpeas
(c) Clover
(d) Cowpeas
(l) Green corn

TABLE IX

Feed Received Up to First Calving. Arranged For Periods of Consecutive Six Months.

No. 2 — Heavy Fed Group

Period	Fat	Solids not Fat	Grain	Hay	Greed Feed
1	57.58	154.64	291.00	48.50	
2	1.70	7.80	1323.80	759.50	
3			1214.50	1362.00	1082.00
4			221.00	166.70 (d) 96.3	
Total	59.28	162.44	3050.30	2433.00	1082.00

No. 8

1	49.7	116.3	213.5	165.5	
2			808.5	213.3 (d) 252.3	(1) 335.7 393.0
3			1120.0	730.3 (d) 261.2	681.5
4			963.0	1160.9 (d) 111.1 (a) 48.2	180.1
5			1046.5	1009.5 (a) 567.8	
6			746.0	1446.2	
Total	49.7	116.3	4897.5	5966.0	1590.3

(a) Alfalfa and clover
(b) Alfalfa and cowpeas
(c) Clover
(d) Cowpeas
(1) Green corn

TABLE X

Feed Received Up to First Calving. Arranged

For Periods of Consecutive Six Months.

Period	Fat	Solids not Fat	Grain	Hay	Green Feed
No. 13			Heavy Fed Group		
1	55.0	163.7	330.5	239.0	
2			865.5	767.5	710.0
3			1399.2	326.6 (a) 504.5 (b) 198.1 (d) 63.8	
4			1154.5	1565.3	
5			168.0	263.0	
Total	55.0	163.7	3917.7	3927.8	710.0
No. 306					
1	80.3	233.4	328.4	248.5	
2			931.0	970.1 (a) 38.5 (d) 92.4	
3			1252.9	127.2 (a) 338.0 (b) 223.3	
4			961.5	323.3 (c) 255.7	
5			237.0	372.5	
Total	80.3	233.4	3710.8	2989.5	

(a) Alfalfa and clover
(b) Alfalfa and cowpeas
(c) Clover
(d) Cowpeas

TABLE XI

Feed Received Up to First Calving. Arranged

For Periods of Consecutive Six Months.

Period	Fat	Solids not Fat	Grain	Hay	Green Feed
No. 216			**Heavy Fed Group**		
1	150.4	307.1	407.3	472.0	
2			1393.5	1033.9	1245.8
3			1257.0	1400.8	1492.5
4			720.0	817.7 (d) 52.0	
Total	150.4	307.1	3777.8	3776.4	2738.3
No. 225					
1	80.5	234.3	371.8	621.0	
2			1010.2	1749.5	
3			1450.5	917.5 (c) 833.2	
4			279.0	342.0	
Total	80.5	234.3	3111.5	4463.2	

(c) Clover
(d) Cowpeas

TABLE XII

Feed Received Up to First Calving. Arranged For Periods of Consecutive Six Months.

Period	Fat	Solids not Fat	Grain	Hay	Green Feed
No. 223			Heavy Fed Group		
1	64.0	197.9	606.5	134.0	
2			1132.4	1331.0	1302.0
3			1472.0	1528.2 (a) 762.6 (b) 146.7 (d) 236.8	
4			1783.0	2127.9 (b) 301.6	
5			283.5	491.0	
Total	64.0	197.9	5277.4	7059.8	1302.0
No. 220					
1	107.2	269.0	437.5	262.5	(1) 204.0
2			961.0	541.6 (c) 18.2 (d) 692.9	(1) 335.7
3			1070.0	1414.2	1247.0
4			1392.0	1245.6 (a) 433.5 (b) 87.1 (d) 99.8	
5			892.0	668.5 (a) 208.5	
Total	107.2	269.0	4752.5	5672.4	1786.7

(a) Alfalfa and clover
(b) Alfalfa and cowpeas
(c) Clover
(d) Cowpeas
(1) Green corn

were calculated from the weekly composite samples using the per cent of fat and the specific gravity according to Babcock's formula.

The hay and green feed ordinarily was alfalfa. When alfalfa hay was not available other leguminous hays were substituted. Green corn was fed in the place of green alfalfa when the latter was not available. Changes from alfalfa hay and green alfalfa are indicated in the foot-notes to the tables.

The totals of the feeds consumed by each animal are given in Table XIII. The amount of fat received by the light fed animals was small. It will be noted that the heavy fed animals received an average of 68.4 pounds of fat more than the light fed animals. They also received on the average about two tons of grain, while the light fed animals received none. On the other hand, the light fed animals received almost five tons of hay, more than twice that consumed by the heavy fed animals and almost twice as much green feed as did the heavy feds. The heavy feds could have eaten as much roughage as the light feds had they so desired, as they were permitted to eat all they wanted. Having as much grain as they cared to eat they ate less hay.

Nutrients Received -- Tables XIV, XV, XVI, XVII, and XVIII show the total nutrients received by each animal, the average received per diem and the average gain in live

TABLE XIII

Total Feed Received Up To Two years of Age.*

Light Fed Group.

Cow No.	Fat	Solids Not fat	Grain	Hay	Green Feed
3	7.9	275.7	---	5417.1	2354.3
11	---	224.2	---	7329.3	1382.0
14	6.3	267.6	---	11519.9	186.0
39	---	326.3	---	4918.0	3116.0
215	---	391.9	---	10657.9	3110.6
219	5.8	273.7	---	14751.4	2168.3
222	---	244.5	---	13846.2	1414.5
224	78.8	227.0	---	8572.1	------
Av.	12.45	278.8		9626.5	1716.4

Heavy Fed Group.

2	59.3 0:	162.4	3050.3	2433.0	1082.0
8	49.70	116.3	4897.5	5966.0	1590.3
13	55.00	163.7	3917.7	3927.8	710.0
306	80.80	233.4	3710.8	2989.5	-----
223	64.00	197.9	5277.4	7059.8	1302.0
220	107.20	269.0	4752.5	5672.4	1786.7
216	150.40	307.1	3777.8	3776.4	2738.3
225	80.50	234.3	3111.5	4463.2	------
Av.	80.80	210.5	4061.9	4536.0	1026.1

*Animals calving under two years are included only to calving time.

TABLE XIV

Nutrients Received in Six Month Periods,

Average Per Diem, and Average Gain Per Diem.

No. 3 — Light Fed Group

Period	Energy	Protein	Energy Per Diem	Protein Per Diem	Gain Per Diem
1	445.22	123.76	2.26	.68	.99
2	655.64	119.60	3.56	.65	.56
3	(5 mo) 670.44	132.88	4.44	.88	.80
4	(4 mo) 686.34	137.76	5.58	1.12	.64

No. 11

1	345.92	129.72	1.84	.69	.87
2	617.21	121.21	3.41	.67	.71
3	912.64	182.16	4.96	.99	.81
4	991.89	199.10	5.48	1.10	.46

No. 14

1	433.36	140.58	2.19	.71	1.00
2	680.00	138.00	3.75	.75	.59
3	955.68	190.05	5.28	1.05	.68
4	1034.08	198.72	5.62	1.08	.60
5	1145.73	229.87	6.33	1.27	.69

No. 39

1	337.34	127.26	1.67	.63	.97
2	539.38	103.17	2.98	.57	.52
3	875.84	130.64	4.76	.71	.77
4	(4 mo) 598.80	120.06	4.99	1.00	.64

TABLE XV

Nutrients Received in Six Month Periods,

Average Per Diem, and Average Gain per Diem.

No. 215 — Light Fed Group

Period	Energy	Protein	Energy Per Diem	Protein Per Diem	Gain Per Diem
1	362.34	160.57	1.98	.79	1.38
2	611.87	166.38	3.89	.86	.70
3	1003.74	142.74	5.48	.78	.54
4	1132.04	212.94	6.22	1.17	.76
5	1608.57	281.82	8.79	1.54	1.22

No. 219

1	416.78	141.96	2.29	.78	1.15
2	715.80	145.36	3.95	.79	.58
3	832.60	166.52	4.60	.92	.99
4	1278.80	252.08	6.95	1.37	1.09
5	1469.72	293.92	8.12	1.62	.55
6	(5mo) 997.56	194.31	6.52	1.27	.84

No. 222

1	441.64	136.96	2.44	.76	1.11
2	730.48	147.20	3.97	180	.57
3	1044.37	202.72	5.77	1.12	1.09
4	1278.80	251.76	6.95	1.39	.65
5	1263.38	240.72	6.98	1.33	.67

TABLE XVI

Nutrients Received in Six Month Periods,

Average Per Diem, and Average Gain Per Diem.

Period	Energy	Protein	Energy Per Diem	Protein Per Diem	Gain Per Diem
No. 224		**Light Fed Group**			
1	561.10	117.65	3.10	.65	1.02
2	673.44	128.80	3.66	.70	.69
3	903.19	179.19	4.99	.99	.74
4	1093.80	207.92	5.95	1.13	.60
5	1186.31	235.36	6.51	1.30	1.00
No. 307					
1	511.88	141.34	2.68	.74	1.08

TABLE XVII

Nutrients Received in Six Month Periods,

Average Per Diem, and Average Gain Per Diem.

No. 2	Heavy Fed Group				
Period	Energy	Protein	Energy Per Diem	Per Diem	Gain Per Diem
1	533.60	80.96	2.90	.44	1.34
2	1348.45	144.80	7.45	.80	1.50
3	1580.76	202.40	8.64	1.10	1.49
No. 8					
1	423.54	61.54	2.34	.38	.66
2	993.60	115.92	5.40	.63	1.12
3	1357.50	164.71	7.50	.91	1.35
4	1288.00	172.92	7.00	.88	.61
5	1377.41	173.76	7.61	.96	.51
No. 13					
1	648.80	111.28	3.20	.52	1.00
2	1054.32	128.80	5.73	.70	.98
3	1534.88	170.54	8.48	.94	1.02
4	1494.08	185.84	8.12	1.01	.53
No. 306					
1	761.54	127.26	3.77	.63	1.38
2	988.20	131.76	8.10	1.08	1.28
3	1138.54	134.39	7.54	.89	.64
4	857.66	87.84	7.03	.72	1.39

TABLE XVIII

Nutrients Received in Six Month Periods,

Average Per Diem, and Average Gain Per Diem.

Period	Energy	Protein	Energy Per Diem	Protein Per Diem	Gain Per Diem
No. 216		Heavy Fed Group			
1	1162.26	176.22	5.87	.89	1.96
2	1659.77	197.29	9.17	1.09	1.30
3	1686.12	187.68	9.18	1.02	1.08
4 (3mo)	872.24	108.58	9.98	1.22	2.02
No. 220					
1	1030.86	151.11	4.98	.73	1.76
2	1371.39	162.90	7.19	.90	1.11
3	1532.72	200.56	8.33	1.09	1.24
4	1763.75	322.18	9.75	1.78	1.44
No. 223					
1	573.46	121.94	4.03	.67	1.82
2	1541.08	200.56	8.37	1.09	1.47
3	2059.78	184.17	11.83	1.57	1.34
4	2406.72	287.04	13.08	1.56	1.07
No. 225					
1	911.80	153.26	4.70	.79	1.85
2	1322.96	189.52	7.19	1.03	1.34
3	1782.85	206.34	9.85	1.14	1.28

weight per diem, by the six month periods. Table XIX gives the average of the nutrients fed per diem thru the first four periods. It will be noted that the animals in the light fed group received on the average less energy in every period than did those of the heavy fed group. The ration of the heavy fed group contained feeds high in energy, i.e. the fat of the whole milk and the corn in the grain mixture.

It is also interesting to note that the light fed animals received more protein during the first period than did the heavy feds. Considering the ration of skim milk and alfalfa hay alone, it is possible to understand how this comes about for that period. The protein received by the light fed animals is less than that received by the heavy fed animals for the 2d and 3d groups and about the same for the 4th group.

The general average for 2 years of nutrients received per diem was made so that the nutrients received by two groups could be better compared. The protein received by the light fed group was only .07 pounds per diem less than that received by the heavy fed group while the heavy fed group received on the average 3.08 more therms of energy per diem than did the light fed group. This difference in the amount of energy received will be referred to again.

TABLE XIX

Average of Nutrients Received per diem in first four periods.

Light Fed Group.

Period	Energy Therms	Digestible Protein Pounds
1	2.27	.72
2	3.64	.72
3	5.03	.93
4	6.10	1.17
av.	4.26	.88
Used for 1b. gain	5.39	1.11

Heavy Fed Group

1	3.97	.63
2	7.32	.91
3	8.92	1.08
4	9.16	1.19
Av.	7.34	.95
Used for 1b.gain:	5.73	.74

Rate of Growth -- Table XX gives the rate of growth by the individuals in the two groups as measured by the gain in weight per diem. The average initial weight of the heavy fed group is somewhat less than that of the light fed group. The light fed group averaged 652 pounds in weight at two years of age, or at calving time if they calved before that age, while the animals receiving the heavy ration averaged 884 pounds at the same time. The light fed group was fed a somewhat longer period than the heavy fed group. This might influence to some extent the average daily gain because as is shown in Table XXI the rate of gain decreases as the animal becomes older. However, as this time is only 38 days it is not probable that the effect of the greater average age on the rate of growth would be appreciable.

Table XXI also gives the average gain per diem by periods, comparing the light fed vs. heavy fed group and the Jerseys vs. Holsteins. As would be expected after a study of Table XX the gain per diem in each period is greater for the heavy fed group than for the light fed group. It is also interesting to note the abrupt decrease in the average rate of gain in the second period of the light fed group. By referring to Tables XIV, XV and XVI, it will be seen that the majority of the individuals in the light fed group gained weight at a smaller rate per diem during the

TABLE XX

Rate of Growth and Gain Per Day

For First Two Years.

Light Fed Group

No. of Cow	Weight at Beginning	Weight at End*	Gain	Days Fed	Gain per Diem
3	50	590	540	685	.79
11	75	593	518	730	.70
14	61	607	546	730	.74
39	50	572	522	688	.75
215	122	731	619	731	.84
219	75	757	672	731	.91
222	108	719	611	730	.83
224	90	649	549	730	.75
Av.	77	652	572	719	.79

Heavy Fed Group

2	35	881	846	548	1.54
8	55	741	686	737	.93
13	52	698	646	730	.88
216	102	1109	1007	653	1.53
220	100	1123	1023	730	1.31
223	90	1136	1046	730	1.41
225	77	1000	923	593	1.55
306	76	897	821	730	1.12
Av.	73	884	875	681	1.28

*Calving time or 24 months.

TABLE XXI

Average Gain Per Diem

In Six Month Periods.

Periods	Light Fed	Heavy Fed	Jerseys	Holsteins	General Average
1	1.04	1.47	0.97	1.50	1.2[illegible]
2	0.61	1.26	0.89	0.96	0.[illegible]
3	0.81	1.06	1.03	1.03	0.9[illegible]
4	0.67	1.16**	0.57	1.14	0.9[illegible]
5	0.77*				0.77

* 1 Jersey
** 2 Jerseys and 4 Holsteins.

second period than during the first or the third. This can probably be attributed to the fact that at the end of the first period the animals were weaned and received nothing but hay from weaning time on. They were unable to consume enough hay to maintain a rapid growth at first after being weaned. After their digestive organs became accustomed to consuming large amounts of hay they ate more and gained at a more rapid rate. As would be expected the Jerseys showed less gain per diem than the Holsteins. The general average of the light and heavy fed groups as shown in Table XXI shows that the average gain per diem gradually decreased for each period after the first until the fourth. The rate of gain was apparently the same for the third and fourth periods, and then showed a decrease for the fifth period. This is what might be expected from our general knowledge of the growth of animals.

In Table XXII is found the average rate of gain per diem of the different breeds in the two groups. Here again in the light fed group both breeds fed thru more than the first period showed less gain in the second period than either the first or the third. It will be noted that the Holsteins gained at a greater rate per diem than did the Jerseys in this group.

In the heavy fed group the Jerseys made less gain

TABLE XXII

Average Gain Per Diem

In Six Month Periods.

Period:	Light Fed Group			Heavy Fed Group		
	Jerseys	Holstein	Ayrshire(a)	Jerseys	Holstein	Ayrshire(a)
1	.95	1.16	1.03	1.00	1.85	1.38
2	.59	0.63		1.20	1.30	1.28
3	.78	0.84		1.28	1.23	0.69
4	.58	0.77		(b)0.57	1.51	1.39
5	.69(a)	0.86				

(a) 1 animal
(b) 2 animals
(c) 3 animals

per diem than did the Holsteins while the Ayrshire fell in between. It is worth while noting that the Jerseys made more gain per diem each successive period than the previous period for the first three periods while the Holsteins gradually decreased in the rate of gain during the same periods. This is not thought to be of any special significance in itself. However, the difference in the rate of gain between the two breeds in the first three periods is slight and there is no marked decrease in the rate of gain in the second period under that in the first period. This indicates that some element of the heavy ration -- probably the grain -- took the place of the milk so effectively that growth was not appreciably decreased when milk feeding stopped. In the heavy fed group the Holsteins averaged greater gains per diem and it also appears that they grew for a longer time.

Referring again to Table XIX we find the average of the nutrients received per diem in the first four periods, and the average gain in weight per diem for the same time. It is interesting to note that there is a difference of more than three therms in the average amount of energy received daily for the first 2 years, the light fed group receiving the smaller amount. The light fed group also received a little less protein per diem than did the heavy fed group, but as this difference is only .07 of a pound

the average amount of protein received daily by both groups can be considered practically the same. It appears that the energy has been the controlling factor in the growth of the light fed group. Of course it cannot be positively stated that either of the groups received enough protein to produce maximum growth. However, as the heavy fed group gained at the rate of 1.28 pounds per diem for the first two years, it is safe to assume that those animals received enough protein to make as much growth as could be desired and would be practical to get on dairy animals. As mentioned above, the amounts of protein received daily by the two groups is practically the same. This being the case it would seem that the energy has been the limiting factor in the growth of the light fed group.

Nutrients required for a pound of growth -- Tables XXIII and XXIV give by periods the nutrients required for a pound of growth by the individuals in each group. On Table XXV will be found the nutrients required for a pound of growth by the two groups. The average by periods and for the first two years is given. This table shows that the heavy fed group required a little more energy for a pound of growth than did the light fed group. This difference seems to be uniformly higher for all periods, but is not very great in total as shown by

TABLE XXIII

Nutrients Required Per Lb. Growth

By Six Month Periods.

Including Maintenance.

Light Fed Group

Period	Jersys			Holsteins		
	No. of Cow	Therms Energy	Pounds Digestible Protein	No. of Cow	Therms Energy	Pounds Digestible Protein
	3	2.28	.68	222	2.19	.68
1	39	1.72	.65	224	3.03	.63
	11	2.34	.80	215	1.43	.57
	14	2.19	.71	219	2.00	.88
	3	6.35	1.16	222	6.96	1.40
2	39	5.72	1.09	224	5.30	1.01
	11	4.80	.94	215	5.55	1.22
	14	6.35	1.27	219	5.81	1.36
	3	5.55	1.10	222	5.29	1.09
3	39	6.18	.92	224	5.66	1.33
	11	6.12	1.09	215	10.14	1.44
	14	7.76	1.54	219	4.64	.92
	3	8.71	1.75	222	10.69	2.13
4	39	7.79	1.56	224	9.91	1.88
	11	11.91	2.39	215	8.18	1.54
	14	9.36	1.80	219	6.37	1.25
	14	9.44	1.89	222	10.41	2.00
5				224	6.51	1.30
				215	7.20	1.26
				219	14.76	2.94

TABLE XXIV

Nutrients Required Per Lb. Growth

By Six Month Periods.

Including Maintenance.

Heavy Fed Group

Period	Jerseys			Holsteins		
	No. of Cow	Therms Energy	Pounds Digestible Protein	No. of Cow	Therms Energy	Pounds Digestible Protein
1	2	2.16	.32	216	3.00	.45
	8	3.51	.57	220	2.84	.41
	13	3.20	.52	223	2.21	.36
				225	2.54	.42
2	2	4.96	.53	216	7.05	.85
	8	4.82	.56	220	6.47	.81
	13	5.84	.71	223	5.70	.74
				225	5.21	.76
3	2	5.79	.73	216	8.50	.94
	8	5.55	.67	220	6.71	.87
	13	8.31	.92	223	8.82	1.17
				225	7.69	.89
4	8	11.47	1.44	216	4.94	.60
	13	15.32	1.90	220	6.77	1.27
				223	12.33	1.45
5	8	14.88	1.88			

TABLE XXV

Nutrients Required Per Lb. Growth

By Six Month Periods.

Heavy vs. Light Fed.

Including Maintenance.

Period	Light Fed Group		Heavy Fed Group	
	Therms Energy	Pounds Digestible Protein	Therms Energy	Pounds Digestible Protein
1	2.15	.69	2.78	.44
2	5.85	1.11	5.65	.69
3	6.42	1.13	7.23	.87
4	9.11	1.70	10.65	1.38
5	9.58	1.88		

the average for two years. The average for the first two years shows that the heavy fed group required .34 therms more for a pound of growth than did the light fed group. It shall not be attempted to explain this difference in the energy required for a pound of growth between the two groups. The difference might come within the limits of experimental error, yet the consistency with which the difference shows up in each period rather indicates that it is correct. It might be explained by the greater maintenance requirements of the heavy fed animals. Animals in as fat condition as these animals were, would surely have a higher maintenance requirement on account of being larger animals than would the light fed animals.

The light fed animals used considerably more protein for a pound of gain than did the heavy fed animals. This is the case in every period and is also very clearly shown by the general average where the difference is .37 of a pound of digestible protein as the average for the first two years. Bearing in mind the fact that the two groups received practically the same amount of protein per diem and that the heavy feds received more than 3 therms energy per diem in excess of that received by the light feds it can be seen that the latter did not require a greater amount of protein for a pound of gain but simply took it because it was in the feed in greater proportion to the

energy. The ration of the light fed group was narrow, or expressing it differently, it contained a much higher proportion of protein than did that of the heavy fed group. The light fed group used less energy for a pound of gain than did the heavy fed group but its rate of growth was slower because the energy in its ration was not sufficient for any greater growth. As was previously stated, the energy seems to have been the limiting factor, in the rate of growth of the light fed group. It may be that the growth of the heavy fed group could be increased by the addition of more energy. However, as already mentioned more rapid gains by growing dairy cattle than those made by this group.could hardly be expected.

Table XXVI compares the nutrients required for a pound of growth by the two breeds in each group. It will be noted here that the heavy fed Holsteins required in the second and third periods somewhat more energy for a pound of growth than did the heavy fed Jerseys. Otherwise, the requirements of both protein and energy for a pound of growth by the two breeds in each group are so surprisingly close that it is thought the differences will come within the limits of experimental error in this work. This means that for growth, the Jerseys and Holsteins use their

TABLE XXVI

Nutrients Required Per Lb Growth

By Six Month Periods.

Including Maintenance.

Light Fed Group

Period	Jerseys: Therms Energy	Jerseys: Pounds Digestible Protein	Holsteins: Therms Energy	Holsteins: Pounds Digestible Protein
1	2.13	.71	2.16	.69
2	5.80	1.11	5.90	1.24
3	6.40	1.16	6.43	1.19
4	9.44	1.87	8.78	1.70
5	(1) 9.44	1.89	(2) 9.72	1.87

Heavy Fed Group

1	2.95	.47	2.64	.41
2	5.20	.60	6.10	.79
3	6.55	.77	7.92	.97
4	(3) 13.29	1.67	8.01	1.10
5	(4) 14.88	1.88		

(1) 1 animal only
(2) Av. of 4 animals
(3) 2 animals only
(4) 1 animal only

feed with equal economy. The exceptional high requirements for a pound of growth by the heavy fed Jerseys in the fourth and fifth periods are due to fluctuation in weights referred to early in this paper.

It has already been shown by Eckles[1] that there is practically no difference in the economy with which cows of different breeds use nutrients for milk production. The facts brought out herein with regard to the use of nutrients for growth bear out these conclusions that the breed has no influence on the economy of the use of nutrients. That the breed does influence the economy with which nutrients are used for production of milk, growth and production is a statement frequently made by practical men.

Kellner[2] suggests the pounds of digestible protein and the starch value a growing dairy animal that is intended for milk production should receive at different ages and the rate of gain per diem at those ages. His figures changed to pounds from kilos and the starch value to therms energy, with a change in the first two periods he gives to make them conform to the periods used in this paper are given in Table XXVII. It is probable that he has in mind animals similar in weight and build to Hol-

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1. C.H. Eckles, Mo. Agr. Exp. Sta. unpublished data.
2. Ernahrung der Landwirtschaftliche Nutztiere, p. 470

TABLE XXVII.

Nutrients required per pound gain and average gain per diem.

(As suggested by Kellner)

Period	Energy Therms	Digestible Protein Pounds	Average gain per diem
1	2.22	.40	1.71
2	5.78	.99	1.22
3	8.15	1.29	.97
4	8.92	1.27	.97
Av.	6.27	.99	1.22

As found at the Missouri Exp. Station.

Light Fed Holsteins

1	2.16	.69	1.16
2	5.90	1.25	.63
3	6.43	1.19	.84
4	8.79	1.70	.77
Av.	5.82	1.21	.85

Heavy Fed Holsteins

1	2.65	.41	1.85
2	6.10	.79	1.30
3	7.94	.97	1.23
4	8.01	1.10	1.51
Av.	6.17	.82	1.47

steins for that type is found in his country. For that reason the requirements he suggests are compared to the actual nutrients required for a pound of growth by the Holsteins in the experiment reported herein. It will be noted that the rate of gain per diem that he thinks should be made by dairy animals to be used for milking purposes is less than that of the heavy fed animals and greater than that of the light fed animals. The protein required for a pound of growth by the heavy fed is less than Kellner suggests might be required, and the same is true of the energy, but to a lesser degree. The light feds required slightly less energy for a pound of gain and considerably more protein, altho as explained before, the protein used for a pound of gain by the light feds may have been in excess of that actually required. This, of course, is what might be expected after the discussion of the difference in the requirements for a pound of gain by the light and heavy fed animals. It would seem therefore that the ration received by the heavy fed group was used more economically than those Kellner had in mind when he compiled his tables.

Growth in fat or frame -- As stated in the Introduction both the groups discussed herein were fed under conditions which would not be generally considered the best practice. It is unusual that growing dairy animals

are given as heavy a ration as the heavy fed group received. As shown by White[1] when the heavy fed animals come into milk after calving their weight is soon to what is generally termed "good milking condition". That is, they are in good condition, but any fat they carry is not visible to the eye. This surplus weight that milks off is probably mostly in the form of fat altho it is impossible to say what proportion is fat. This surplus fat can not properly be termed growth, but it is included in the weight and reported as "gain". It is very probable that the growth of the muscular and skeletal systems of the heavy fed animals was not so much in excess of the light feds as the gain in weight would indicate. On the other hand, it may be that the tissues of the light fed animals contained less fat than would be found in animals fed according to ordinary practice. The growth of this group as indicated by gain in weight may be more than is shown in this data. It would be necessary to make an analysis of the bodies of at least one of each group in order to definitely decide this question and that might not suffice. Data should be gathered at some future time on animals fed what might be termed a normal growing ration.

The growth of the animals as determined by skeletal measurements such as the height of the withers and

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1. White, G. C. Thesis for Degree of M. A. Univ. of Mo. 1912.

pin bones when compared to the gain in live weight ought to give information as to the fairness of measuring growth by gain in weight.

It being a fact that the light fed animals did not grow as rapidly as the heavy feds when growth is measured by gain in weight and it being probable that the skeletal growth was less, as has been mentioned, the protein received by both groups being the same the energy was evidently the limiting factor in the growth of the light fed group. It might be that neither group received as much protein as it should have received altho this is hardly probable. While the data at hand gives some indication it is not sufficient to justify any conclusion as to what amounts of energy and protein are necessary to obtain the most desirable growth by dairy cattle at different ages.

Suggestions for Further Investigation.

It was brought out several times in the discussion of the experimental work that there are several important points concerning the nutrients required for growth by dairy cattle that are not clear from the available data.

(1) The normal weight of the different breeds of dairy cattle at various ages should be determined. This question has been brought up in several places during the study here reported. It is important to both the practical

dairyman and the scientific man that this as well as the question of what is the normal ration to feed growing dairy cattle at various ages, should be answered.

In this connection it is well to mention the unaccountable fluctuations in the weight of the animals from day to day. This should be controlled as much as possible, and in addition to measuring the growth of the cattle by live weight, certain skeletal measurements should be made.

(2) A more accurate determination of the energy required for the most rapid growth of dairy cattle at different ages should be made.

It is probable that the actual skeletal growth made by the heavy fed group reported herein could have been made on less energy as it is known that the growth of the heavy fed group was partly surplus fat which was milked off the body after the animals calved. It would probably be necessary to kill and analyze the bodies of several animals for the proportion of fat, lean and bone, before this point could be cleared up. These animals would be representative of those fed on rations similar to those discussed in this paper and in addition at least one fed an amount of energy ranging about midway between the two and containing the same amount of protein.

(3) A further study of the protein required for the best growth at different ages should be made. In the

ration of the two groups fed and reported herein the average amount of protein fed daily was practically the same. It is not known whether the animals of either group received enough protein for best growth or whether they received an excess of that necessary for best growth providing the amount of energy received was sufficient. It is important that the protein requirements of growing dairy animals at various ages be determined.

(4) Another point that was studied in some of the preliminary work but which is not included in this thesis is the relation of the season of the year to the rate of growth and to the nutrients required for a pound of growth as measured by gain in weight.

CONCLUSIONS

This paper merely introduces the study of the growth of dairy cattle now in progress at the Missouri Experiment Station. The data at hand is not sufficient to permit a complete study of the nutrients required for growth. However, the study of the data obtained from the work with two groups of animals the one on a heavier ration and the other on a lighter one than it is customary to feed to growing dairy cattle has brought out some facts of importance.

(1) The maintenance requirements for growing cattle suggested by Armsby do not apply to dairy cattle.

(2) The data collected from sixteen animals showed that it required an average of 5.56 therms energy to produce a pound of growth up to two years of age.

(3) The average growth per diem by dairy cattle as measured by gain in weight is greater the first six month period of their lives and gradually decreases thereafter.

(4) Holstein cattle make greater gains per diem up to two years of age than do Jersey cattle.

(5) The energy required for a pound of growth by animals on a light as compared to a heavy ration is practically the same provided they receive as much protein

in the light as in the heavy ration.

(6) Animals of different breeds require practically the same nutrients for a pound of growth.

(7) The nutrients required for a pound of growth increase with the age of the animal.

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