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THE NORMAL GROWTH OF
DAIRY HEIFERS

by

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NORMAL GROWTH OF DAIRY HEIFERS.

INTRODUCTION.

The Federal Office of Farm Management reports (March, 1914) that there are 21,749,651 dairy cows in the United States. Considering the average productive life to be six or seven years, it is evident that 3,000,000 to 3,500,000 heifers must be grown each year to maintain the present number of dairy cows. The Government estimate of the cost of raising each to a productive age is \$61.41. It therefore is important, not only that they be economically grown, but that they make such growth as will result in greatest production at maturity.

A review of literature shows that little has been done experimentally on the growth of dairy cattle. While the scientific facts of growth have

been worked out with man and with laboratory animals, almost no application of these facts has been made to the development of farm animals.

The basis of this thesis is a study of growth of dairy heifers from birth to first parturition. The development of animals kept under different planes of nutrition is considered and compared with that made by those fed rations which are thought to be suitable for normal growth. From this data a standard of growth is calculated showing the size a heifer should attain at any particular age.

GROWTH

Definition -- Growth is the sum of the changes thru which the animal body passes in its progress to maturity. It is the means by which an individual reaches its final size and consists primarily in increasing weight and stature by the formation of new tissues. Growth primarily involves cell division which Henry H. Donaldson¹ defines as follows: "The constituent cells of the body enlarge, divide, and in turn enlarge, at the same time that some of them cease to divide further. The number of these latter cells increases rapidly, while the relative number of the dividing cells diminishes. As to the absolute number of the dividing cells with advancing age, our information is very meager. The body increases in weight so long as the dividing cells continue to multiply and the others to enlarge. In addition to the other circumstances which contribute to growth, it appears to be due in large part to the accumulation of cells, which at any given time have attained more or less full size and in which further growth has practically ceased."

According to Marshall² growth in embryonic stages is characterized by the increase in the numbers of cells. Of later growth he says, "In the later stages of development, growth occurs largely thru cell enlargement and the

1. Anatomical Record, Vol. V, 1911.

2. F. H. A. Marshall; "The Physiology of Reproduction."

deposition of inter-cellular substance."

To define growth accurately requires a thorough knowledge of the nutrition, chemistry and physiology of the animal body. In general practice, it may be said to be the increase in body weight or stature which can be estimated by weights and skeletal measurements.

Rate of Growth -- The common method of measuring growth is by the changes in weight or in stature or by using both of these measurements. While these methods prove an accurate means of determining increase, they do not offer a measure of the rate of growth. Minot¹ points out that rate is best found by calculating the percentage increase during a definite period of time and not by the absolute gains during the same time. Therefore a 200 pound animal gaining 2 pounds per day has a much higher rate of growth than one which weighs 1000 pounds and gains 3 pounds daily.

Rate of growth varies with the phase of life. It is greatest in prenatal life - being at its maximum just after fertilization, declining rapidly following birth and then gradually declining until growth ceases.

Minot², in studying embryo chicks and rabbits, estimates that over 98 per cent of the original power of growth is lost before hatching or birth. He believes

1. Senescence and Rejuvenation. Jour of Phys. Vol. IXII, 1891.
2. Jour. of Physiology, Vol. 12 (1891).

that this fact is equally applicable to man and says:
"We start out at birth with less than 2 per cent of the original growth power with which we were endowed. Over 98 per cent of the loss is accomplished before birth - less than 2 per cent after birth".

Curves illustrating the rates of growth in man, guinea pigs, rabbits and chickens indicate that it is clearly correlated with age, and that the periods in life in which there is most rapid development are also those of most rapid decline in the power of growth. Contrary to this view that the rate of growth is dependent upon the age is the opinion of Davenport¹ that "the reason why the animal ceases at length to grow is not because there is a necessary limit to growth force at a certain distance from impregnation but because it is in the nature of the species that the individual should cease to grow at this point." The indefinite growth of this part, the limited growth of that, are as much group characters as any structural quality". Also Ferry² in studies with growth in rats shows growth to be a function of size rather than age. Rats which were stunted for prolonged periods were afterward capable of growing at a "rate normal for their size rather than for their age". The balance of experimental evidence seems, however, to correlate very closely the rate of growth in

1. Experimental Morphology, Davenport, Part 2, Chap. 10, '99.
2. Anatomical Record, Vol. VII, No. 12.

any normal individual with its age.

Wilson¹ in his studies in cytology writes, "During the individual development the energy of cell division is most intense in the early stages and diminishes more and more as the limit of growth is approached".

Marshall² agrees that the "process of growth goes on with gradually decreasing frequency thruout practically the whole of life; tissue formation continues but from an early period of development onwards there is a progressive diminution in the power of growth."

From results obtained in studying litters of pigs and comparative figures for man, rabbits, rats and chicks, L. G. Lowrey³ says, "All these forms agree with the general law that the rate of growth is by far most rapid at the beginning of prenatal life, decreasing at first rapidly then more slowly thruout prenatal and post-natal life".

Dr. Minot⁴, working with growth in different mammals, also points out that the "rate of growth diminishes almost uninterruptedly from the time onwards when the animal recovers from the post-natal loss of weight. This diminution is rapid at first but afterward slower.

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1. The Cell in Development and Inheritance.
 2. F. H. Marshall, "Physiology of Reproduction"
 3. Amer. Jour. Anat. 12 (1911) No. 2 pp. 107-108.
 4. Vol. XII Jour. of Physiology. (Senescence & Rejuvenation)

There is a progressive loss in the power to grow, beginning almost immediately after birth. The loss of growth power is equally demonstrable in the case of man (as in guinea pigs) and there can be little doubt that it is true at least of all mammals".

The "post-natal loss of weight" to which Dr. Minot refers has long been noticed in man and seems to be true of other mammals. This check in rate of growth comes immediately following birth and lasts from two to five days. It varies with individuals and with sex, being much more distinct in the male, often causing relatively heavy losses. "Male guinea pigs lose weight as do new born children for a variable period of a few days after birth. In both sexes, the weight is retarded at birth but much more in the male than female, so much in fact that there is an actual loss".¹

Growth Comparisons -- Insufficient data is available to allow conclusive comparisons of growth in different species of animals. Relatively large numbers of weights and measurements on humans have been made, the most notable in this country, being those on St. Louis and Boston school children. The only other extensive source of statistical information on growth, however, is found in studies with the smaller laboratory animals.

1. Senescence and Rejuvenation. Jour. of Phys. Vol. XII, '91.

Ferry¹ has found that growth curves for normal animals are very similar to comparable ones for other types of animals. To plot comparative growth curves in different species necessitates chart compensation for variation in size of the animal, length of life, etc. This increases the probability of error and makes the comparisons of questionable value except that all show a fair degree of uniformity in the decline in rate of growth.

While definite growth laws have been worked out by Minot, Bowditch and others for the particular class of animals with which they experimented, it is not proved as yet that these laws are applicable in all mammals. It is interesting to note, however, that the processes of metabolism in the guinea pig, for example, are more nearly correlary with those in cattle than with those in man. Rubner² has compiled data on the growth of man, horse, cow, sheep, pig, dog, cat, rabbit and guinea pig which show that human growth is a distinct type and differs widely from that of the other mammals named. As an illustration he notes that while it requires 4808 calories of food to form one kilogram of animal weight, it takes six times this amount for man. In

1. Anatomical Record Vol. VII, No. 12.

2. Rubner, "Das Problem der Lebensdauer und seiner Beziehung zu Wachstum und Ernährung". 1908.

this respect, these mammals, with the exception of man are alike in that the same percentage of food energy goes to growth. This percentage averages about 34 per cent, that is, for every 100 calories of food energy, 34 are used for growth, while in man, on the other hand, only 5 per cent is taken for this purpose.

Data has been collected by Marshall¹ on absolute growth in different animals. "The mean weight of the foal at birth is said to be 112 pounds. During the first three months, the average daily increase is 2.2 pounds; from three months up to six, 1.3 pounds; and from six months to three years, .7 pounds. The calf averages at birth 77 pounds and makes an average daily increase for the first two years of 1.5 pounds. With the sheep, the increase is greater, for a young lamb in ten days can add 50 per cent to its original weight, can double it at the end of the first month and treble it at the end of the second. In pigs, however, the increase is even more rapid, for a young pig can add 20 per cent to its original weight by the end of the first week - and up to the end of the first year, can add an average daily increase of .44 pound."

"In man, growth is most rapid during the first year of life, when a child is about to increase its

1. F. H. A. Marshall, "The Phys. of Reprod".

weight by 200 per cent. For the second year, this percentage drops to 20 and for subsequent years up to the age of 13, it fluctuates around 10, showing a gradual tendency to decrease."

Considerable variation from the normal rate of growth is often noticed. Growth being at times, much slower and at others more rapid than for the average. Young animals show this to a greater degree than older ones. Bowditch¹ found from many measurements with school children that, first, "any irregularity in the growth of an individual tends to be followed by an opposite compensating irregularity and, second, that variability in rate of growth diminishes with the age". Evvard² writes, "An animal does not seem to grow regularly but on the whole there is a tendency toward a normal rate of growth, which rate, even adverse conditions do not seriously interfere with unless carried to extremes".

On the influence of age on rate of growth, Waters³ writes, "Gain in body substances by well nourished young animals is relatively much greater than by mature animals even when fattening. The unweaned calf may increase 2 to 3 pounds daily for each 100 pounds of body weight, while a gain .3 to .4 pound daily per 100

1. 8th Annual Rpt. of the Bd. of Health of Mass. 1877.

2. Evvard, J. M., Thesis for the Degree of M.A. Univ. of Mo., 1909.

3. Proceedings of the Soc. for Promotion of Agr. Sci. '08.

pounds of body weight is large for the mature, fattening ox. The more rapid increase in weight of young animals is due to several causes, their flesh contains more water, their food is more digestible and concentrated, and they consume more feed in proportion to live weight". Work at the Wisconsin Station and the studies of Soxhlett¹ add as a fourth cause, the greater economy of the young animal in the use of its food. Wisconsin² lambs fed cow's milk gained 1 pound in weight for each .75 pound of dry matter consumed. Soxhlett, in respiration studies with a calf 2 to 3 weeks old, found a storage in the body of 72.5 per cent of the protein, 96.6 per cent of the lime and 72.6 per cent of the phosphorous fed in the milk, showing the very high storage of digested food nutrients in the young animal.

X Growth Limit -- "All animals and plants have a limit of growth"³ and each individual strives toward it in its development. Dr. Minot⁴ has suggested that all growth is the result of an impulse given at the time of impregnation which determines the final size to which an animal may grow. "³When the limit is attained, a more or less definite equilibrium is established, some of the

1. Ber. landw. chem. Vers. Stat. Wien, 1878, p. 101.
2. Wis. Research Bul. No. 24.
3. Wilson, "The Cell in Development and Inheritance".
4. Senescence and Rejuvenation, Jour. of Phys. Vol. XII, '91.

cells ceasing to divide and perhaps losing this power altogether, others dividing only under special conditions while others continue to divide thruout life and thus replace the worn-out cells of the same tissue. . The limit of size at which this state of equilibrium is attained is an hereditary character which in many cases shows an obvious relation to the environment, and has been, therefore, and is maintained by natural selection".

FACTORS INFLUENCING GROWTH

Sex -- Besides the variation in the inherited tendency to grow are the sex growth differences. The male of most of the higher species is larger at birth and maturity than the female. Studies of growth curves of both sexes in different species evidence wide variations in rate at different times, particularly at the time of sex maturity. Menard¹ showed the pre-pubertal superiority of female giraffes at two years and that after puberty the males have greater height. With guinea pigs, Minot found the females smaller at birth, decidedly larger at the end of the first month and when adult, larger. He writes, "The sexes do not vary alike - the male being larger during the larger part of growing period altho smaller at maturity. The diminution of growth in both sexes, altho greater in amount and longer in duration in the female, begins about at the end of the fourth month. The double pubertal fluctuation of growth may occur in all mammals".

Bowditch² describes the growth of children as taking place in such a way "that until the age of 11-12 years, boys are both taller and heavier than girls of the same age. At this period of life, girls begin to

1. Thesis, "La Croissance", Paris, 1885.

2. 8th An. Rept. of Bd. of Health of Mass., 1877.

grow very rapidly and for the next two or three years, surpass the boys in both height and weight. Boys then acquire and retain a size superior to that of girls."

The effects of sex on growth seem to be:-

1st. That at maturity in the higher vertebrates at least, as a rule, males are larger than females.

2d. That wide variations in rate of growth occur at the time of sex maturity when females are frequently larger than males of similar age.

Internal Secretions -- The exact influence of "internal secretions" on growth is not known. The name, internal secretions, is given to products produced by special glandular organs (ductless glands) and poured directly into the blood. Schäfer¹ believes that "the activity of the cells responsible for growth is controlled in some degree by chemical agents (hormones) circulating in the blood". The chemical composition of hormones is defined by Schäfer¹ who says that "they are organic bodies of a not complex nature, far simpler than proteins and even than enzymes".

Important among the glands now definitely known to influence growth are the testes and ovaries, the pituitary body, the thymus, the thyroid and the pineal body.

1. Schäfer - "Nature" Vol. 90, p. 17.

That the removal of the testes or ovaries influences the general metabolism and growth is evidenced as noted by Abderhalden¹ by the almost universal tendency of castrated animals to lay on fat. Louvy² points out also that "in castration the bones of the limbs tend to be longer than in the normal". This phenomena has been described in castrated guinea pigs, oxen, capons and various animals. "The injections of testicular substance", according to Louvy, "into young capons, causes the development of the normal skeletal characteristics".

The pituitary body, a small structure attached to the base of the brain, influences growth. Schäfer³ found that its hypertrophy results in the over development of the skeleton. He concludes that, "only a part of the organ produces hormones which stimulate the growth of the body generally and of the skeleton particularly".

Howell⁴ says, "The secretion of the anterior lobe of the hypophysis (pituitary body) is connected with the processes of growth, particularly of the skeleton".

A strong influence on growth is exerted by the hormone secreted by the thymus. Howell⁴ reports

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1. Abderhalden, Emil, "Textbook of Physiol. Chem." p. 600
 2. "Physiologie der Geschlechts" Vol. II, 1903.
 3. Schäfer- "Nature" Vol. 90, p. 17.
 4. Text on Phy. Chem. Howell.

that the removal in young animals results in, first, a stage of increased fat formation and, later one of malnutrition which manifests itself strikingly in the atrophic and undeveloped condition of the bones. The thymus and testes are closely related in their effect on growth, the loss of either resulting in a compensating development in size and function by the other. Hart and Nordmann¹ working with dogs, showed the removal of the thymus alone to result in delayed growth and sexual maturity. The simultaneous removal of both organs results in checking growth, Paton² proved this fact with guinea pigs.

The effect of the thyroid upon the growth tends to connect it with the thymus and testes. In growing animals³ the loss of function of the thyroid gland results in a late development of the length of bones. Normal production of the secretion of the pineal body seems to affect an inhibitory action on growth and the result of diminished activity of the gland is an increased growth of the skeleton.

Experiments with animals carried on different nutrition planes develop the fact that all tissues of the organism are not similarly affected, that in many

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1. Berl. klin. Wochsch. 1910, p. 815.
 2. Jour. of Physiol. 42 (1911) No. 4.
 3. Text on Phy. Chem. Howell.

cases certain tissues, as the mammary glands, grow independently of the rest of the organism. It is supposed that their growth is started or regulated by specific secretions or hormones. Kellicott¹ summarizes the subject, "It seems likely that in organisms in general the normal growth of each tissue or even each organism is controlled separately by a specific internal secretion. These substances may regulate growth either thru inhibition or acceleration and the effect produced may be due either to the presence or the withdrawal of the specific substance".

Amount of Food Supply -- Among the environmental factors influencing growth which lie within control is that of food supply. Experimental evidence seems to show, however, that the food supply is not closely correlated with growth, particularly of the skeleton, as is sometimes thought. A young growing animal uses its food mainly for these three purposes, maintenance, growth, and storage. The first of these needs to be met is maintenance. The remainder of the food goes for growth and storage, depending in proportions, according to Evvard², upon the age. "The younger the animal, the stronger is its tendency to use its food for growth

1. Verhandl. Internat. Zool. Kong. Graz. VIII (1910 pp. 597 - 601.

2. Evvard, Thesis for the degree of M. A. Univ. of Mo. '09.

and the less body fat is stored". So strong is this tendency that even though young animals are not maintained in weight, they may grow and continue to do so for long periods¹. The growth tendency of the skeleton is so strong that other tissues are absorbed to furnish the necessary tissue: Aron² found that young growing dogs if given a diet insufficient to maintain their body weight still continue to grow, the skeleton increasing in size at the expense of the other tissues, particularly of the muscular tissues.

The chief effect of scanty food supply as compared with liberal feeding is to delay maturity³. It seems generally true, however, that within a particular type in any breed the final skeletal growth is greater and the growth completed earlier, other factors being equal, when the animals are heavily fed.

Aron⁴ has proved it possible by supplying suitable amounts of food, to maintain a dog in an emaciated condition, apparently in good health, and at the weight of a puppy for nearly a year while its weight at the end of the year should be three times as great. If such an animal is thereupon fed amply, it fattens and rounds out, but does not reach the size of a control animal which from the beginning has been normally fed.

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1. Work by Trowbridge on Maintenance at Univ. of Mo.
 2. Phil. Jour. of Sci. Sec B (1911) VI
 3. Unpublished data, Mo. Sta. by Eckles
 4. Phil. Jour. of Sci. Sec. B (1911) VI.

Bowditch¹ in studying the effect of food supply and general care of children on growth reports, "Children of American born parents are taller and heavier than children of foreign born parents, a superiority which seems to depend partly on the greater average comfort in which such children live and grow. . . . Sons of non-laboring classes are decidedly taller and, at most ages, also heavier than the children of the laboring classes. The occupation of the parents (that is, the conditions of food supply, etc., which they are able to furnish their children) has a very decided effect on the size of growing children".

Waters² reports that variations in food supply effects growth in the following ways:-

1. A uniform, ample food supply results in a steady growth from birth to maturity.

2. Periodical variations in nutrition planes cause food storage during liberal feeding so that growth continues without serious checking during the light feeding following. Rate of growth is considerably increased during heavy feeding to partially compensate the decreased rate in low ration time.

3. Continued light feeding causes a lower rate of growth but the period is greatly prolonged.

1. 8th An. Rep. of Mass. Bd. of Health.

2. Proc. Soc. for Prom. of Agr. Sci. 1908.

4. An animal under conditions of prolonged light feeding grows by making more economical use of its food than when well fed.

Difference in Food Required for Repair and Growth -- Mendel Ferry and Osborne¹ have pointed out that metabolism during growth differs from that of later life, also that the requirements for growth and maintenance are separate and distinct. "The fact that certain proteins, lacking in one or more cleavage products, known to be necessary to the formation of the proteids of the animal body, are of relatively high efficiency in preventing loss of body nitrogen due to metabolism, yet are insufficient for growth, forces one to the conclusion that the processes of replacing nitrogen degraded in cellular metabolism are not of the same character as the processes of growth".

Effect of Specific Proteins -- The Wisconsin Experiment Station² has shown that growth varies with the presence or absence of certain specific amino acids in the food supply of protein. The proteins of a single plant are "incomplete" and "animals fed rations from different plant sources and comparably balanced in regard

1. Carnegie Inst. Bul. No. 156.

2. Hart, McCollum, Steenbock and Humphrey, Wis. Research Bul. No. 17.

to the supply of digestible organic nutrients and production terms were not alike in respect to general vigor, strength and size of offspring and capacity for milk production". Results at the Wisconsin Station¹ in growing heifers on rations made up wholly of corn, wheat or oat products give positive evidence for "the necessity of giving much weight to the physiological influence of the ration apart from its digestible protein content and calorific value".

Considerable difference of opinion exists as to the value of specific proteins as sole sources of the protein of the ration. For example, The Wisconsin Station² fed growing heifers on a ration made up wholly of corn products, 58 per cent of the principal protein of which is zein, with the results that "those animals receiving their nutrients from the corn plant were strong and vigorous, in splendid condition and produced young of great weight and vigor".

Willock and Hopkins³ working with the same protein say, "Zein, it is clear, has no power whatever of maintaining growth in the young animal; loss of weight begins the moment it forms the sole nitrogenous supply". Osborne⁴ has found "that there is a very great difference in the food value of different proteins.

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1. Hart, McCollum, Steenbock and Humphrey, Wis. Res. Bul, 1 7
 2. 28th Rep. Agr. Exp. Sta. of Wis.
 3. Journal of Phys. Vol. 35, p. 881.
 4. Science, Vol. 37, p. 105.

Thus we have complete nutritive failure with zein,
maintenance with gliadin, and restoration of lost
weight or normal growth with either casein, lactal-
bumin or edestrin". Osborne, Mendel and Ferry¹ re-
port zein among the proteins which are not able "to sup-
ply all the complexes necessary for growth". Zein was
shown "very efficient in repairing losses due to tissue
metabolism but no additional body tissue was formed from
it, proving the repair processes to be of a different
character from the processes of growth". While "results
obtained experimentally serve to show that the presence
or absence of some one amino-acid in the diet may effect
materially the general well-being of an animal", it is
true that few rations, especially if composed of a va-
riety of feeds, are lacking in protein requisites for
growth. Feeds supplying the quantitative protein will
likely furnish the various amino-acids.

Mineral Requirement -- Little is known of the
laws governing the metabolism of mineral matter but, the
frame-work of bone, partly of protein but largely of min-
eral matter, is in general subject to the laws that govern
the formation of protein tissues",² The quantitative
requirements of mineral have not been worked out. A.
Gouin and P. Andouard³ have shown that the feeding stand-

1. Carnegie Inst. Bul. No. 156.

2. Henry, "Feeds and Feeding", p. 71

3. Bul. Sta. Agron., Loire, Inferieure (1902-3) pp. 66-100.

ards are not accurate in this respect - that "calves require smaller amounts of the chemical elements making up powdered bone than the Wolff standard calls for". Soxhlet¹ in complete metabolism studies with calves found that "a very much larger quantity of mineral matter is retained by the suckling calf than by the adult animal".

Various skeletal deficiencies have been traced to inadequate mineral supply in early life. Abnormally low growth has at times been made by young animals fed milk which has been boiled. In European countries where the practice of "cooking" milk is followed, there are reported very high percentages of abnormal bone growths resulting in deformities. The common disease of children "rickets" has been attributed to scanty supplies of lime salts in the food. Howell² believes however, that the lime supply is generally sufficient and that it is more probable that "the cause of the faulty calcification of the bones is due to a diminished assimilation of lime. It is likely that the function of those cells whose duty it is to assimilate the required calcium does not excite itself normally". A preliminary mineral requirement test has been run by the Experi-

1. Ber. landw. Chem. Vers. Stat., Wien, (1878), p. 101.
2. Howell, "Text of Physiological Chemistry".

ment Station of the University of Missouri¹ which seems to indicate that under ordinary conditions, the supply of mineral matter is not the limiting factor of growth, that until more complete metabolism experiments are run, it is only necessary to furnish ordinary farm rations containing sufficient quantities of the other nutrients to take care of the mineral requirements.

Need of a Standard Measure of Growth -- The study of growth in farm animals has been given but little attention experimentally. While some work has been done with growing animals under abnormal conditions of nutrition the only statistical information available as to the growth a normal individual should make is in results with "check" animals. This data is too incomplete and the conditions under which it has been gathered too variable to make it of much value.

The growth of one, or at best a few animals, may not constitute an accurate "check". Any individual is subject to such wide variation from the average that its use in experimental work as a measure of normal growth may render the conclusions drawn of questionable worth. Even tho this is recognized as true, however, it is not always practicable to use a large number of animals simp-

1. Woodward, E. G. Thesis for the degree of M. A., Univ. of Mo., 1913.

ly to indicate a standard by which to judge experimental results.

Again, the man in practical work has no criterion by which to estimate the growth of his animals. Experience teaches him to judge one animal as "well grown" and another as "stunted" but he has no means of accurately determining whether he is under or overfeeding, whether an individual of a given age is above or below the average of its breed in size.

Thus far, even in experimental work, the only determination of size which is commonly used is that of weight. Gains in mature cattle of the beef breeds may thus be quite satisfactorily reported and are fairly comparable. However, the inaccuracies which arise in estimating changes in dairy cattle, especially in young animals make calculations in pounds gain or loss of little practical value as a measure of growth. To record the weight of a calf as 300 pounds tells practically nothing of its growth -- whether it is "stunted" in skeletal development but heavily fleshed or whether its weight is largely made up of growing tissues.

An individual heavily fed from birth on a highly concentrated ration may be thickly fleshed and not be distinguished by the measure of weight from another much

better grown but lower in condition. Nor are supplementary explanations of the condition of an animal sufficient to greatly lessen the difficulties of comparison. The lack of uniformity in terms defining different degrees of fleshing makes exact description impossible. What is "good growing condition", for example, to one judge may be described quite differently by another.

It seems, therefore, that weight alone is not an accurate measurement for cattle, especially young, growing animals. A standard is needed which will measure the growth an individual has made by taking into account both the condition of fleshing and the skeletal development.

PURPOSE OF THIS INVESTIGATION.

This investigation has been carried on to meet the need of a uniform standard for growth as it relates to dairy heifers:

1. By determining what constitutes normal growth in dairy heifers - by finding what size a normal individual should reach at any given time during the growing period.
2. By combining weight and skeletal measurements to establish a standard which offers a uniform measure for growth.

It is not the purpose of this paper to discuss the chemistry, physiology and nutrition requirements of growth. Such a discussion could be properly dealt with only by experts in these lines.

The source of considerable of the data here presented prevented further observations of growth other than by skeletal measurements. It is obvious that a paper based on data of this kind cannot take the place of a physiological study of growing tissues. The object of this work is simply to furnish a means of accurately measuring growth in dairy animals.

EXPERIMENTAL DATA.

Source of Data -- Normal growth could best be determined by recording changes in weight and stature thruout the growing period of a "normal" individual kept under normal conditions. Since there is no means of knowing at the birth of an animal what its growth will be and since the factors which cause variations in growth cannot be accurately controlled, this method appears impracticable. Howell¹ in studies on growth concludes that "the perfectly normal development of all the physical faculties would require a rare combination of favorable circumstances. In dealing with a large number of individuals, variations disappear in the general average and the deficient development of one individual is balanced by the excessive growth of another". The normal growth curve as determined in this paper is based on data collected on a number of growing dairy heifers kept, as nearly as possible, under normal conditions of growth. It seems probable that the average growth curve of these animals approximates the normal.

For purposes of comparison, data on dairy heifers in which growth varies from the average is presented. This includes growth measurements on animals on

1. Howell - Textbook of Physiology.

exhibition, those given light and heavy rations and those kept under widely abnormal conditions of feeding.

Conditions for Normal Growth -- To make these growth measurements comparable with those which may be made in the future by others, the care and management of the dairy heifers, from which the data to be given was taken, is described. These conditions are believed to be those suitable for normal growth.

Cows in calf are kept in "good condition",
neither thin nor heavily covered with flesh. In most cases, calves suck their dams but once or twice and are put in a pen by themselves when a few hours old, in no case are cow and calf left together more than two or three days. During the first four or five days, calves receive as much of their dam's milk they will drink, morning and night, - the amount varying from about 10 pounds daily for Jerseys to as much as 12 or 14 pounds for Holsteins. Milk containing 3 per cent to 3.5 per cent fat is then substituted gradually for that of the dams. At two weeks of age, Jersey and Ayrshire calves receive 9 to 11 pounds daily and Holsteins 12 to 15 pounds. At two to three weeks

of age, skim milk gradually takes the place of the whole milk so that at three or four weeks, Jerseys and Ayrshires are given 12 to 14 pounds and Holsteins about 16 pounds of skim milk, no whole milk being fed. This amount is usually increased to some extent as the calf becomes larger. They are weaned at 5 to 7 months of age.

Clover hay and a mixture of 2 parts corn chop and one of oats by weight are fed as soon as the calf will eat. Pure water is always supplied and stable conditions are such that fresh air and sunlight are abundant.

When pastures are good, calves, after weaning time, are turned on grass and the grain mixture withheld. If pastures are "short", small quantities of hay and grain are fed thruout the summer. Under winter conditions, heifers over 6 months old are fed a ration made up of corn silage and alfalfa or clover hay with not over 2 pounds of grain per day.

Heifers are bred to calve at about 24 months of age for Jerseys, and 28 for Holsteins. Usually pregnant heifers are fed corn silage and alfalfa or clover hay in winter with about 2 pounds of grain daily. In summer pasture grass is the exclusive ration unless

the feed is short, when some grain is fed.

These conditions of management result in most cases in healthy, vigorous growth to maturity. The heifers are uniformly kept in what may be defined as "good growing condition".

To check the data collected on the growth of normal heifers, measurements were taken on dairy heifers being grown under practical conditions near Columbia. These heifers had been fed from birth with the idea of developing them most economically for heavy production at maturity. They were not "pushed" but fed to make healthy gains. At the time of measurement they were in slightly poorer condition than were the Station heifers. The heights were taken on animals 9 to 14 months of age and "checked" very closely with the data on "normal heifers".

Data on Normal Heifers -- The animals from whose growth the normal standard for growth is calculated are dairy heifers being grown at the Iowa and Missouri Experiment Stations under conditions as defined above. The cattle at the former Station were measured but twice and furnished only about 30 measurements while growth figures on those at the Missouri Station were taken from October 1913 to April 1914, giving in all a little less than 200 individual measurements.

Only three breeds, Holsteins, Jerseys, and Ayrshires, are used, the data from Guernseys being too limited to furnish reliable data.

Data on Exhibition Heifers -- Thru the kindness of the exhibitors at the Iowa Dairy Cattle Congress at Waterloo, Iowa, and the National Dairy Show at Chicago, about 300 height measurements were obtained of heifers on exhibition. Appended to this paper is a list of the herds from which this data was secured. In nearly all cases, the animals were in excellent growing conditions at time of measurement and in a higher state of flesh than is commonly observed with dairy heifers. When conditions were clearly abnormal¹ measurements were discarded. Data was collected on cattle from a territory stretching from New York to Oregon and from Canada to Texas.

Light and Heavy Fed Heifers -- Statistics on growth on two lots of dairy heifers, one light fed and one heavy fed from birth, have been used in establishing correlations of growth as indicated by different skeletal measurements. These animals which were kept under fairly extreme conditions show the difference in development of dairy heifers due to unusual feeding.

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1. The calves in one herd were coarse and clearly overgrown. Inquiry revealed the fact that they had been "forced" from birth by heavy feeding on concentrates and by allowing them to suck until several months of age - conditions clearly not in harmony with practical dairy methods.

Growth curves from the averages of these two groups have been drawn for comparison with that of normal animals.

Birth Weights -- The weights at birth of all calves in the University of Missouri herd have been taken for the past 10 years. The data used in this thesis is that compiled by Reed¹ and later by Graves¹ from these records with the addition of those records not included in the compilations mentioned. This includes weights on 79 Holsteins, 128 Jerseys and 23 Ayrshires.

Growth of Calves for First Thirty Days -- To ascertain the gains made by calves during the first thirty days after birth, weights were taken daily on 9 calves. Weighings were made each afternoon just before feeding time. This data includes weights on 6 Jerseys and 3 Holsteins.

MEASUREMENTS.

Measures of Growth Used -- In gathering data on growth in dairy heifers, two measurements were used: weights and heights.

The figures used represent averages of weighings made on the 14th, 15th and 16th of each month.

1. Formerly assistants in Dairy Husbandry - Mo. Station.

The weights were all taken in the morning at about the same hour and in all cases before the animals were fed or watered.

Two measurements of skeletal changes were used, (1) the height in centimeters at the highest point of the withers, and (2) the height in centimeters at a point midway between the hook bones. The height measurement was used because it seems to combine best with weight in determinations of growth. Weight measures fairly accurately the increase in tissue structures; skeletal measurements are used to indicate changes in skeleton; a combination of the two seems a practicable measure of total growth.

Correlations of Skeletal Measurements -- In order to determine whether height measurements can be used as a measure of skeletal changes, the growth of various parts of the skeleton as shown by measurements available from the light and heavy fed heifers on experiment at the Missouri Station, were tabulated and correlated. The data given is that collected from 18 different skeletal measurements on the two different groups of Jersey heifers. These being selected because of the larger numbers of animals of this breed which are in the experiment. Of the available measurements, four were selected to compare with the

height at withers. These four are, (1) depth of chest, (2) width of hooks, (3) length from withers to hooks and (4) length from hooks to pin-bones.

These measurements when given in centimeters vary greatly in totals. To reduce them to a comparable basis, the total increase from the end of the first month to calving time was taken and divided into six-month periods. The percentage of total growth to the first parturition was calculated on these six-month periods. The result of this work is shown for both the heavy and light fed groups in Table I. The data on the light fed animals is more comparable than that on the heavy fed for two reasons:- first, there is a larger number of animals considered for a longer period of time; and second, the figures on the heavy fed animals are taken from two sets, the first group calving at about 20 to 28 months of age at which age measurements on the other group were just being collected. A more detailed study is therefore made of the light fed animals.

The data for the light fed animals reveals a striking uniformity when the number of individuals and the possibilities for variations in measurements are considered. Table 2, which presents the aver-

age of the four measurements contrasted with the wither percentage, summarizes the results. From this data it appears that animals grow more in proportion in height during the first six months than they do in the other measurements. A similar increase is noticed from 24 to 28 months but is probably without special significance.

It is of interest to note that the correlations in growth are so close that a variation of one measurement in any period is usually associated with a like variation in the others. For example, the rapid increase in the wither heights in the 18 to 24 month period with light fed animals is also shown in the average of the other four measurements. The percentage variation appears high. However, a centimeter's difference in measuring will in the majority of instances throw the balance in the opposite direction. Calculating the percentage of variation on so small a basis emphasizes differences.

These tables point out that growth in the different parts is closely correlated - that data on the increase in one, measures the increase in another. From these figures it seems that skeletal changes can be indicated by accurate measurements of the animals. In this work, therefore, height at withers and hooks

is taken as a measure of the general skeletal growth.

Variations in Measurement -- All weights are necessarily liable to positive and negative fluctuations. A positive error because the digestive tract normally contains large quantities of non-digested matter; also the bladder may contain more or less quantities of urine. Negative errors result from every illness, such as digestive disorders or even slight injuries which cause more or less loss of weight. These variations in most cases are comparatively unimportant - the positive errors tending to counterbalance abnormally low weights so that the averages are probably approximately correct.

A variation in weight which is as yet unexplained is that which occurs from day to day, differences of as high as 50 pounds being observed with mature animals. While this is less with growing animals, it is, nevertheless, great enough to cause noticeable changes in weight. Differences in intestinal and bladder content do not account for it as proved at the Missouri Station where an animal was kept on scales and all feed given and all excrement weighed. Under these conditions, daily weighing showed as high as 30 to 40 pounds unaccounted variation. Regan¹

1. W.M.Regan, Ass't. in Dairy Husb. Mo. Sta.,

has suggested as an explanation a difference in the moisture content of the cells. From metabolism tests in other animals, this appears true, that protein tissue represents a fairly constant weight in any animal and is scarcely responsible for variations in weight. The water and fatty material of the body seem to be the most variable factors.

Height measurements are also accompanied by unavoidable errors, making the data obtained greater or less than the true height. As in weight variations, however, these inaccuracies tend to compensate each other in averages.

Differences in condition may prove a factor in influencing height measurements by varying the thickness of the fatty tissues over the withers and hooks. Trowbridge¹ has proved this to be of but slight significance. He fed a Jersey cow so that her condition at different periods was described as "common", "medium", and "good". During this time height measurements changed but 1.25 c.c. at the withers and .5 c.c. at the hooks. This variation is of even less importance in the study of normal growth since all animals were kept in uniform growing condition. -- -- Excepting the slight influence of this factor variations

1. P.F.Trowbridge, Prof. Agr. Chem. - U. of Mo.,

in height, as nearly as could be determined, were below normal rather than above.

The nervous and excitable temperament of dairy animals makes exact calculations of size by skeletal measurement very difficult. Height figures taken on a dairy heifer at one time may vary as much as 1 to 3 centimeters from those taken under other conditions. So great is the probable error in measurement that data taken on the growth of a single animal, however closely its growth curve approaches the normal, may not be exact. It seems more accurate, therefore, to establish a standard by averaging data taken on several individuals.

Several factors have been noted which may give rise to errors in data. Measurements taken during oestrus are liable to inaccuracies due to the difficulty in keeping the animal from moving while heights are taken. Illness or injury of any kind, and nervousness or excitement lessen the exactness of data.

As far as possible, all causes of variation in measuring were eliminated. The heifers furnishing the growth data were accustomed to being handled and generally stood quietly during measurement. In all cases, heights were taken on a smooth, level floor with the animal standing squarely on its feet.

DISCUSSION OF DATA.

Birth Weight of Calves -- Birth weights of 230 calves in the University of Missouri dairy herd are used in estimating the birth weights of Jerseys, Ayrshires and Holsteins. Several stations have published data on this subject based, for the most part, on comparatively few weights. The figures herein presented are from birth weights of 128 Jerseys, 79 Holsteins and 23 Ayrshires. It seems probable that data from this number of individuals indicates fairly accurately the average birth weights for the different breeds.

Table 3, a summary of all weights, shows the average birth weight as 55 pounds for Jerseys, 70 pounds for Ayrshires and 90 pounds for Holsteins. Breed may, therefore, be considered an important factor influencing the size of calves, resulting, as shown by this data, in about one-third more weight at birth in Ayrshires than in Jerseys and about one-third more in Holsteins than Ayrshires. Besides this weight variation is that which occurs within the breed, for no exact figure will by any means apply in all cases. While there are occasional extreme weights, by far the

greater per cent of individuals come within 8 to 10 per cent of the average.

As pointed out in the review of "growth literature", sex distinctly effects the size of calves. By this data, Table 4, males of all breeds are shown to be heavier at birth than females. Jersey bull calves are approximately 4.5 or 8.7 per cent larger at birth than heifers; Ayrshires 10.75 pounds or 16.5 per cent, and Holsteins 6.75 pounds or 7.8 per cent. The relatively small number of Ayrshires weights is thought to account in part for the extreme sex variation in weight in that breed.

The per cent of the weight of the dam which the calf's birth weight constitutes has been calculated. The dam's weight represents the average of weights taken for 3 days closely following parturition. Table 3 shows that the per cent weight birth of Jersey calves to that of their dams is 6.37 per cent; Ayrshire calves 7.43 per cent, and Holstein calves 7.99 per cent. So many factors tend to vary weights that accuracy in estimating the weight of calf a certain cow will drop is hardly possible. The above per cents, however, offer some indication.

Graves studied part of the data on birth weights. Calculations of the figures brought up-to-

date substantiate his conclusions that (1) large dams are apt to have large offspring tho this does not hold true to the extent of being proportional to the increase in the weight of the dam; (2) mature cows have larger calves than do immature ones; (3) the condition of the dam has very little influence on the weight of the calf at birth unless the dam is excessively fat when the offspring are generally smaller, and (4) that the sire is an important factor among the influences which effect the birth weight of the calf.

Growth During First Thirty Days -- Table 5 presents the weights taken on the individual calves during the first thirty days after birth. The average daily gain for the entire period as presented in Table 5 is .93 pounds. The average calculated from the individuals in this table is misleading in that it denotes that the calf has as high a rate of gain per day immediately following birth as it has toward the end of the thirty day period. If the weights of two calves number 214 and 219 are omitted, the average weight at birth is 60.29 pounds, and 60.7, 61.0, 62.0, 61.93 respectively for the following four days. The majority of the calves

show a tendency to lose weight or at best gain very slowly for the first few days following birth. This period varies in length from two to five days and corresponds to the period in the human family which Minot has described when new born babes lose weight. The calves during this time appear healthy and normal in every way. It is thought that the change in physiological conditions affect the calf so vitally that only a small gain in weight is made immediately following birth.

This data is also compiled by ten day periods in Table 6. These results show that the calves gained fastest during the third or last period. They also indicate that the calf gains the least during the second ten days when the average daily gain is only 0.73 pounds. The average gain for the first period is .87 pounds, and 1.19 pounds for the third. The low daily gain may be traced to digestive disorders of some of the calves, notably No. 9, 41, 102 and 124. Where conditions are such as to prevent these troubles, proportionally higher gains may be expected. Weights taken on healthy calves may be expected to show equally as fast gains during the second period as the first. The results of the preliminary study show that the calves grow very slowly the first few

days after birth and that the gain per day during the first month increases with the age. While the calves in this experiment gained .93 pounds per day during the first month, daily gains of 1 to 1.7 pounds according to breed may logically be expected.

During the first few weeks of growth, height measurements were taken on these animals at three day intervals. The data is not given in table form because it was too variable to be of practical value. The total gain in height during the first month as determined by these measurements is from 3 to 6 cm. or an average daily gain of 0.1 to 0.2 cm. Variation is also caused by the difficulties experienced by making the calves stand normal long enough to take accurate measurements. For example, calf No. 9 showed the following measurements at withers on the 1st, 4th, 7th, and 10th days:- 69.5, 68.0, 70.0, and 68.5 respectively. This variation while not extreme, shows the wide fluctuation during the first few weeks in height measurements.

Growth During the First Twelve Months -- The growth of dairy heifers during the first year is very rapid, especially if the rate of growth be measured by height alone. Breed variation is also shown quite clearly in these measurements. Of the total gain made in

height from birth to parturition as calculated from normal data given in Table 7 and summarized in Table 8 the Jersey makes four-fifths, the Ayrshire three-fourths, and the Holstein two-thirds during the first year. The larger proportion in the case of the Jersey is attributed to the early maturity of that breed while the later maturing characteristic of the Holstein explains its relatively low percentage.

As shown by Table 8 the greatest increase in height comes during the first three months. Growth during the second three months is shown to be but slightly less. The rate of increase rapidly declines after the first six months, the average monthly gain being about one half as much the second six months as the first. Thus in the Jersey breed, while the total gain from the second to the sixth month is 25.9 cm., it is but 14.1 during the second six months; while with the Holsteins, the increase in the measurements for the same periods are 26.5 and 11.4 respectively.

The proportion of total weight that an animal attains during the first year of growth is relatively less than the increase in the animal's stature. While the average Jersey heifer will weigh two-thirds as much at the end of the first year as she does at parturi-

tion, as shown in Table 8, the Holsteins and the Ayrshires weigh only about half, altho the latter weigh a little more proportionally than do the Holsteins. The breed difference in the weight attained does not seem to be so clearly marked as the difference in height.

The average weight of Jerseys and Ayrshires at six months constitutes one half of the total twelve months weight. This shows, therefore, that the average daily gain is greater during the second six months than it is during the first. The absolute rate of growth, however, is greater the first six months, decreasing uniformly with advancing age. The average daily gain of the Holstein heifers did not vary widely during the entire period, being about 1.3 pounds. The other breeds showed average daily gains of 1.0 and 1.3 for the Ayrshires and Jerseys.

A study of the individual growth reveals some facts not noted in connection with the summarized report for the gains made the first year given in Table 8. The older the animal becomes, the greater is the actual deviation in weight of the extreme individuals from the average, but the same does not hold true when height is considered. It is also true that the percentage de-

viation of the animals from the average in wither measurements decreases with age much more rapidly than is the case with weights in which the percentage deviation remains higher for a longer period of time. The actual deviation of the wither measurements does not vary widely thus reducing the percentage deviation. On the other hand the variations in weight increase so that the percentage deviation does not decrease. The rapid decline in the percentage variation in the animals in height may be interpreted to signify that the probability of error in measuring decreases slightly with age. It does show that the variation of an animal from the normal height is relatively less than the deviation in weight.

A study of the data collected was made with a view of ascertaining the amount of prepubertal acceleration, if any, that was present. As Bowditch has noted in studying high school children, the average does not show as large a deviation as the individual for obvious reasons. In attempting to correlate the gains made with some acceleration with of this kind, difficulty was encountered in detecting the difference in rapidity of growth due to care and individuality con-

trasted with approaching sex maturity. The number of normal animals considered is too small to form definite conclusions, but it is doubtful if any distinct rapidity of growth could be associated with sex maturity.

With the averages for the heavy fed animals at the Missouri Station, however, there appeared a period from six to nine months with the Jerseys and the seventh to ten months with the Holsteins which was accompanied with an accelerated rate of growth. Some individuals showed the same tendency more strikingly than others. For example, No. 217 gained 71 and 54 pounds during the 9th and 10th months; No. 227 gained 50 and 58 pounds during the 8th and 9th months; No. 225, 48 and 55 pounds during the 9th and 10th months; No. 216, 67 pounds during the 7th month; while the gain of the entire group of heavy fed Holsteins averaged 43.3, 45.6 and 51.3 pounds during the 7th, 8th and 9th months contrasted with 31.9 and 33.3 pounds during the 6th and 10th months respectively. It is interesting to note that these animals reached sexual maturity, as indicated by the first period of heat, at an average age of 262 days. This indicates that in heifers as in other animals there

is an accelerating growth tendency during the pre-pubertal period. The heavy fed Jerseys showed heavier gains during the 6th and 7th months, denoting that if the acceleration is present in this breed it comes at an earlier age. This is to be expected when the characteristics of the breed are noted, but is not sustained by the data at the Station, which gives the age of sexual maturity for this breed as 284 days. This seems abnormally high, however, and it is believed that the acceleration, if present, would undoubtedly appear earlier.

Growth After the First Year -- The rate of growth between the end of the first year and parturition appears more uniform than that made during the first twelve months. Considering the animal from the standpoint of height, it is to be expected, from the data given in Table 7, that the heifer will gain from 0.5 to 1.0 cm. per month. No marked difference in rate of gain due to age can be noted during this period. The Holsteins increase more rapidly than either of the other breeds represented which is attributed to the later maturity and increased height of that breed.

Variations in weight increase during this period. It is not unusual for the average of the group

to remain nearly constant for as much as two or three months, due to this variation and the small number of animals on which data is available. While the average gain per day of the Holstein heifers remains nearly as high as during the previous year, those of the other two breeds shows a marked decrease in the average daily gain. The gains per day for this period for the different breeds are:- .6, 1.1, .7 pounds for the Jerseys, Holsteins and Ayrshires respectively. The heavier gain of the Holstein heifers as has been indicated is to be expected in studying the growth of the heifers of the various breeds.

In considering the growth of normal heifers nearly as much may be shown by a study of the individual growth as by considering the average alone. Thus when a large number of weights and measurements are absolutely essential for the formation of a normal growth curve for dairy heifers, all the facts may not be apparent in the tabulated data. By this method of study, it is noted that two animals of the same breed apparently under similar conditions vary widely in their power of growth as indicated by weight and skeletal measurements. To illustrate, No. 83 and No. 86 under conditions which were practically identical, show that while the

one heifer weighed 500 pounds at 17 months, the other reached the weight at 11 months of age. At 22 months of age the weights for these two heifers were 647 for No. 83 and 722 pounds for No. 86.

It is noted that exceptionally rapid gains are usually followed or preceded by correspondingly slow gains. Weights taken at the Missouri Station during May, June and July, 1913, illustrate this point. Heifer No. 313 gained 59 pounds or from 418 to 477 pounds from May 15 to June 15. The month following this heifer gained only 4 pounds. Similarly heifer No. 237 gained 64 pounds during the month from May 15 to June 15 and only 17 pounds the following 30 day period. These examples could be multiplied showing the same influence that is apparent in the above illustrations.

Table 8 showing the average growth of animals also presents the range of variation. A close examination of the factors affecting growth and the records kept of the growing animals, fails to show the cause of variation in the power of growth. With the weights and measurements of the station cattle where the animals are kept under uniform conditions, little variations due to environmental factors might be expected. However,

the rate of growth seems to vary widely. While growth may be influenced by a number of different factors under ordinary conditions, the differences given in this thesis save of the animals fed for exhibition purposes cannot be so attributed. The power of secretion or hormone causing growth, seems to vary with the individual. The differences in individuality which express themselves in this manner may be due to corresponding differences in what Aron¹ has pleased to call the "growth tendency".

A comparison of the height and weight measurements reveals the fact that the former increases faster in proportion in the early months of the heifers life. Whereas the growth is four to six times as rapid in height the first three months as it is from 15 to 18 months, the gain in weight is relatively uniform. It is to be noted, that gains from 12 to 18 months are more uniform in weight and height than in the later periods. This may be attributed partially to the difference of the early maturing characteristics of individuals, altho the period of pregnancy does not influence the heifer so much at this age. During the second year while the heifers gain but one cm. per month in height, the increase in weight is from 20 to 40 pounds.

1. Biochem. Ztschr. Vol. 30, p. 207.

Many of the heifers measured were pregnant during part of the period in which data was collected. It is not believed that this has a marked effect upon the growth of the animal in height, altho it probably increases the animal's weight. Minot¹ states that gestation does not represent a tax upon the parent but a stimulus; it does not impede growth but on the contrary favors it. Guinea pigs which had given birth to young showed, three days after delivery, an excess in weight over that of virgins of the same age and breeding. Whereas the latter weighed 532.1 gms. the average of the others was 588 gms., a difference of 10.5 per cent in favor of those females which had been pregnant.

The wide variations from the average limit the usefulness of the average given. In order to present a table which would be more nearly comparable, the data is presented in Table 9 in the form of percentage increase. That is, the percentage increase for each period is based on the weight or height at the beginning of that period. For example, the percentage increase for the first period of six months is calculated on the figures for one month of age, since height measurements

1. Jour. of Physiol. V. 12, 1891.

of the calves at birth are not reliable.

It can readily be understood that the figures thus collected will be applicable more or less closely to heifers that deviate widely from the standard. To illustrate, if a heifer weighs three-fourths of normal weight at 12 months of age she will in all probability weigh slightly more proportionately than this figure at 18 months. It is appreciated that the pull of the mean or the average of the breed tends to bring the individual towards the normal as Galton has shown to be true in the human family. It is believed, therefore, that the average of normal heifers, supplemented by the percentage increase, will prove a more reliable guide than the numerical standard alone.

Light and Heavy Fed Heifers -- The growth of the light and the heavy fed heifers of the three breeds is summarized in the tables which present the averages, the two extremes and the number of cattle considered. The small number of animals tends to make the growth curve less uniform than was to be hoped. Since these statistics, however, include data taken on the same animals at different ages, the results are believed to be reliable. The absolute increase, by month periods, for

these groups, is also presented in Table 15 where the relative importance of weights and skeletal measurements is considered. These two groups of heifers seems to vary most widely in their fleshing tendencies, the heavy fed group excelling the light fed group in weight at all ages. The difference between the two groups is most marked towards the close of the second year, after which the difference narrows as the age increases.

Table 10 presents the data calculated on the percentage increase basis previously explained. A careful study of this table emphasizes the difference between these two groups in their rate of absolute growth for the three breeds represented. It also points out a difference in the methods represented in measuring growth, showing what has been suggested, namely weight increases faster during the early months in proportion to the height measurements than during the second year.

Table 10 also shows the skeletal growth tendencies to be greater than the stimulation of growth in the soft tissues. This is evidenced by the fact that an animal which for any reason receives less food nutrients than those necessary for normal growth may sacrifice growth of its soft tissues to permit of nearly normal

skeletal development. A study of the light fed group denotes this relation since their growth in stature remained more nearly normal than did their increase in weight. On the other hand the heavy feds while they slightly exceeded the normal in height, grew faster proportionately when measured by weight. The rate of skeletal development is seen, therefore, to deviate less from the normal and to be influenced to a smaller degree by the nutrients supplied than is the growth of the soft tissues. The conditions from 24 to 36 months are more abnormal because under ordinary management, the heifers would have calved before reaching this age.

As previously noted growth literature attributes the development of an animal to the action of a specific secretion or hormone. The growth an animal makes is also influenced by the amount of nutrients supplied, light feds making less and heavy fed slightly more growth as denoted by Chart I than animals fed a normal ration. / The individual inherent growth tendency may explain variations from normal growth which are not due to the differences in the environmental conditions. However, since the animals in both the light and heavy fed groups are of the same breeding, the variations in growth cannot be so attributed.

Comparing the light and heavy fed groups of Jerseys, it is noticed that the heavy feds grew faster in both weight and height than the light fed heifers during the first 18 months. After this period the light fed cattle had a higher rate of growth than the other group, save for the sixth period which requires a word of explanation. In the heavy fed group, the measurements of only two animals were available for the sixth period. These animals were both larger than the average, thus raising the percentage of gain for the sixth period unduly. Therefore, the conclusion is justifiable that the heavy fed heifers grew faster during the early period only to be superseded during the later periods by the light fed.

An examination of Table 11 giving the growth of these two groups shows that the light fed heifers were always smaller than the other group. Thus while light fed animals gained faster during the later periods, they did not reach the size in either weight or height of the other group. However, they came nearer reaching the heavy fed group in height or skeletal development than they did in weight. This is in accordance with the theory which has been advanced that emphasizes the stronger character of the skeletal growth tendencies.

It is very probable, as the height indicates, 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 show. On the other hand, it may be that the tissues of the light fed animals actually contain less fat than would be found in a normal animal. A comparison of the heavy fed group with the normal shows that the heavy feds were apparently in a higher state of condition due to heavy feeding.

The Holstein group differs more markedly from the conditions given for the Jerseys in that the light fed Holsteins gained the faster during the third periods as well as during the later periods than did the heavy feds. The difference in the rapidity of gain in the Holsteins is also much greater during the first period than in the case of the Jerseys. The reason for the light feds in this group gaining faster in the third period while the converse is true in the Jersey group is not apparent. The earlier maturing Jersey would naturally be expected to reduce its rate of growth earlier than the Holstein which is not indicated by the tables.

The Ayrshires in this experiment number only

four animals which accounts for the extreme variation shown in Table 11. The light fed animals gained as rapidly in height as did the heavy feds. When weight alone is considered, however, the heavy fed animals were larger during the entire period previous to calving.

Comparison of Light and Heavy Fed Animals With Normal -- A comparison of these two groups of heifers for the three breeds with the average of the normal heifers is graphically shown in chart I. Since the difference is characterizing the different breed groups have already been shown, the discussion here will include the relation of the general groups to the normal.

When weight is considered, the heavy feds are seen to excell those of normal size from the early months to first parturition. This difference varies somewhat in the different breeds but is usually the greatest between 15 and 24 months of age. In the case of Holsteins, the heavy fed heifers at 9 months, average 100 pounds heavier than the normal. As age increases, this difference becomes greater until at 16 months it reaches 200 pounds. / The difference in the case of the Jerseys is not so pronounced, the two groups

running practically uniform until one year old.

At 17 months, the difference reaches 100 pounds from which it does not vary widely during the rest of the period. The heavy fed groups are thus seen to excell, not only the light fed animals in weight, but also the normal as well.

On the other hand, light fed animals fall below the normal in weight during the entire period previous to calving. The Jerseys variation reaches 100 pounds at 11 months which difference remains practically constant. At 12 months, the light fed Holsteins are over 100 pounds below normal; this variation from normal increases slowly from this age until parturition. The Ayrshires are not considered because of the few animals on which data is available.

The heavy fed animals of the two breeds, Jerseys and Holsteins, vary widely in their relation to the normal height. While the normal and heavy feds in the Jerseys continue to be about the same in stature from birth to parturition, the heavy fed Holstein heifers grow faster in height than the normal and are especially higher after the 10th month. The number of animals considered, while not large, renders the results reliable. The increased growth of the heavy fed Hol-

syreens as compared with that of normal, seems to be due to the extra food nutrients given. On this basis, the only explanation for the fact that the heavy fed Jerseys made approximately the same growth as normal feds is that they received but little more food nutrients than required for normal growth. Additional support for this conclusion is furnished by the heavy fed Ayrshires which made considerably higher growth gains than those fed a normal ration.

All the light fed animals fall below the normal in rate of height development. This difference, while perhaps the greatest between the 10th and 21st months is clearly perceptible during the entire period considered. It shows that the light feds received too little food to permit of normal skeletal development, altho it does not necessarily indicate that the light fed heifers were "stunted" in their growth. The growth curves of the two groups given in Chart I indicates a strong tendency on the part of the light feds to closely approach the normal in the last few months previous to parturition.

The comparison of the light and heavy fed animals of the Missouri Station with normal animals indicates that the variation in the two groups is much

greater when weight is considered than when height is compared. The tendency of the heavy fed group is therefore to lay on flesh, while the poorer fed animals lack the fat and muscular development especially, of the normal animal, but make relatively good skeletal gains. The heavy feds and normal heifers in the Jersey breed have approximately the same average height, altho both the Holstein and Ayrshire heavy fed groups are taller than the normal of their respective breeds. On the other hand, all the light fed animals were smaller even in height, than the normal, altho the proportional difference was less in height than in weight. This indicates that the hormone or secretion responsible for skeletal development is stronger than the corresponding stimuli for flesh development, and the height measure of growth may therefore be more accurate than the weight.

Growth of Heifers at the Michigan Station -- H. W. Norton, Jr. reports in Michigan Bulletin No. 257 the results secured in raising over 60 calves. Complete records were kept on 7 pure bred Holstein heifers. The feeds given these calves were whole and skim milk, corn meal, ground oats, bran, oil cake, dried beet pulp, silage, roots and leguminous hays.

"These calves were all registered animals, and were fed liberally to give good growth and flesh". From data secured from this bulletin and Mr. Norton personally, Table No. 12 is calculated. This average weight is very high, due largely to the feed. It shows the variation from the normal that can be made if the calves are pushed from birth and corresponds fairly closely to gains of the heavy fed animals. Skeletal measurements on these heifers are not available. The deductions made from the heavy fed animals at the Missouri Station will probably apply with equal aptitude to the work of the Michigan Station.

Growth of Heifers at the New York Station --

The Cornell Station publishes in Bulletin 269 some data on the weight of calves at different ages. For the purposes of comparison, it seems inadvisable to use all the weights given since some of the calves were fed on milk substitutes. Accordingly in Table 13 the averages given are taken entirely from those calves fed skim milk. It can be seen from this table that while the Jersey animals are slightly larger than the normal at the Missouri Station, the number of animals is too small to make the difference appear significant. In the case of the Holsteins, however, the weights cor-

respond very closely to those taken at this Station, denoting the animals at the Missouri Station are normally fed.

Animals on Exhibition -- Table 14 which gives this data in a tabulated form presents not only the average for the months considered, but also the two extremes. Conditions were such that it was impracticable to secure weights on these animals. The majority of the animals were in good show condition and carried more flesh proportionately than heifers raised under ordinary conditions. It is probable that therefore, were the weights available the differences between this group and the normal would be accentuated due to the heavy fleshing carried by these heifers. While the number of animals measured seems relatively large, the individual variation is too large to permit a very uniform average. Since these animals came from a very wide range of territory, the climatic conditions in the respective states as well as the breeding and feeding materially influences the growth of the animals. For example, the herd of Jerseys owned by Mr. John B. Stump of Oregon averages ~~averages~~ noticeably larger than the Jersey herds which came from the Corn Belt.

The Holsteins fed for exhibition purposes
are taller than the normal being equal to or even
surpassing the heavy fed group. From 6 to 18 months
with no exceptions and again from 24 to 27 months in-
clusive, the exhibition animals are higher at the
withers than the heavy feds. At only one month, the
21st, does this group fall to normal and this is ex-
plained by the fact that both animals making up this
average were under sized from the breed standpoint.
It is evident, therefore, that the heavy feeding of
the show animals increases the rate of growth not only
in terms of weight but also in centimeters of height.
If the normal animals are fed enough to permit of nor-
mal skeletal development, then the conclusion is inevit-
able that the heavier feeding of the show animals in-
creases the rate of growth, no matter how that measure
of growth be taken.

The stature of the Jersey heifers exhibited
at the Fall shows is uniformly less than the average
of the normal after the first five months. The number
of young animals is too small to make this exception
significant. While this appears to be a contradictory
finding, a study of show-ring animals explains it. The
normal data in this thesis was collected entirely on

American bred Jerseys. The type exhibited was uniformly the smaller, finer Island type. While it is believed that the heavy feeding customary for showing, exerts a considerable influence in increasing growth, it is not sufficient to counterbalance the greater size of the normal heifers due to a difference in type.

Considering the general average or growth curve formed by the limited number of animals which constitutes the Ayrshire group it is evident that the show heifers form the highest average of any group that has been considered. While the number of animals makes the curve very ununiform, it can be seen from the Chart that the show animals are uniformly larger after nine months, with the exception of the normal animals from 13 to 19 months. It is likely that the type of animals fitted for show does not vary greatly in their power of growth from the animals of this breed in the herd at the University of Missouri Farm.

This data denotes that the exhibition animals of the Holstein and Ayrshire breed are larger while those of the Jersey are smaller than the Station heifers for the respective breeds. This latter dif-

ference is accepted as due to the smaller type of the breed. Incidentally this work illustrates the desirability of following a larger number of animals from birth to maturity in order to secure uniform results. While the number of animals considered is greater than either those of the light or heavy fed groups, the curve of growth is much more irregular. Where a number of animals are measured but once, very large numbers are essential to secure even approximately true curves. Where the same group of heifers are followed month after month, abnormalities disappear and an average curve with fewer irregularities as that of the heavy or light fed animals, is the result. The work required to secure a curve in this manner would require measurements on fewer animals but necessarily would cover a longer period of time.

The Best Measurement of Growth -- As early as 1878, an attempt was made to measure growth thru metabolism studies. Up to this time, however, no conclusive results have been presented and no means of accurately estimating the growth by calculating the metabolism of the body has been evolved. Should future studies of this kind furnish a measure of growth, it will, at least, be a valuable supplement to a grow-

th standard calculated from weight and skeletal measurements.

At present height and weight measures
seem the most practicable means of describing the
development an animal has made. The immediate
problem deals with the relative importance of these
two measures as an accurate guide for estimating an
individual's growth. It has previously been shown
that the withers height alone is a fairly accurate
measure of skeletal development, and can therefore
be used to the exclusion of various other skeletal
measures that have been devised. The small varia-
tion in the rapidity of development in the width of
hooks compared to the height at withers is so small
that it may easily be more than offset by unavoidable
errors in measurement.

The relative value of the height and weight
measures of an animal can better be understood by
knowing the errors to which each may be subject. As
has been noted variations in height especially in
young animals are caused by a number of factors. It
is generally understood that an animal will vary in
weights taken on successive days under apparently iden-
tical conditions. These variations are not confined

to daily weighing for, they are also found when the weights are considered by monthly periods. The precaution of averaging three days weighings does not obviate this difficulty which is plainly apparent in Table 15. This table gives an example of such variations and shows where the animal apparently lost weight and decreased in stature as well. The majority of the animals considered do not show as extreme variations as are presented in this table, but fluctuations of a similar nature are frequent. It has been suggested that a rapid increase in size is often followed or preceded by a period of less growth activity.

A decrease in height may not be followed by a corresponding decrease in weight. Neither does the shrinkage in weight apparently necessary involve a decrease in stature. Altho during a long period of time, increase in height would, under ordinary conditions, be accompanied by a gain in weight. During monthly periods, however, correlations between the two measurements is difficult to perceive. Table 16 gives the average monthly increase of all the Holstein and Jersey groups on which both measurements

have been taken. A careful study of these tables reveals no correlation between average increase of height as compared to weight. For example, an increase of 1.92 cm. in normal Jerseys from 16 to 17 months is associated with the decrease in weight of 15.66 pounds. Likewise from 8 to 9 months, a decrease in 0.4 cm. in height is accompanied by a 44.53 pound increase. Other examples from these tables could be given to show that increase in stature is not necessarily correlated with an increase in weight.

From the work previously given in the discussion of light and heavy fed cattle, the inadvisability of using either measurement separately has been indirectly shown. The conflicting conclusions which may be drawn from these two measurements show that both of these are essential to a correct interpretation of the growth of an individual. The most accurate means of measuring growth seems to be the combination of weight and skeletal measurements. By combining weight with height of an animal, that animal's growth can be determined very closely. If an animal has been under fed, the individual will be below the average in both respects. The poor to medium fed animal

will be of the normal height but probably deficient in weight. The well grown stuff will deviate but little from the average, while the animal which has been pushed, will be heavier in weight than the average. The height measurement will serve as a guide to the skeletal development. Because of the different conditions which a growing animal may be in, weight cannot serve this purpose adequately. The measures of weight will serve as an index to the muscular development of the individual, which skeletal measurement does not indicate.

STANDARD FOR DAIRY HEIFERS.

The results secured from the data taken on the normal heifers forms the basis for the standard growth curve given in Chart 2. In compiling this chart the data on light and heavy fed heifers and the show animals has been used to supplement the normal data, especially where the latter was based upon comparatively few statistics. The irregularities of the normal growth curve have thus been smoothed out to form the standard.

The height and weight of dairy heifers of the three breeds according to the growth standard is presented in Table 17. This table is based upon too few measurements to be considered as a final average. It is believed, however, that this standard will furnish an accurate guide to normal growth. Any standard of growth must be simply an approximation in its application to individuals. It is appreciated that individual heifers will vary more or less from any average, but the standard as calculated is believed to represent the average growth of normal dairy heifers.

SUMMARY.

While skeletal measurements may form a more reliable guide to an animal's growth than weight, they are not an accurate index in themselves. It has been shown that a single skeletal measurement, preferably of height at withers may be accepted as denoting the growth of the different skeletal parts. The height of an animal increases relatively more uniformly than does weight and is also less affected by environmental conditions. The period of greatest growth in height development is during the first six months, the rate of growth decreasing with advancing age.

Daily weights on new born calves denote a post natal retardation of rate of growth lasting from two to five days. Individuals vary widely in their behavior in this respect, but no difference due to sex was noticed.

Monthly measurements of growing heifers seem to denote a prepubertal acceleration in rate of growth. This increase was most marked in the case of the heavy fed heifers. This period of accelerated growth varies with the breed and the plane of nutrition, apparently being hastened by heavy feeding.

Light feeding apparently retards the rate of growth, especially during the early months, in which case the growing period is lengthened. Heavy feeding on the other hand increases the rate of growth and hastens maturity. The mature size of the two groups does not vary widely.

The Holstein and Ayrshire heifers on exhibition were larger than the normal animals as found in the Experiment Station herds. Jerseys, however, were smaller which is due to the refined Island type found in the show ring.

The statistics gathered on normal heifers indicates that the Jersey attains four-fifths, Ayrshire three-fourths, and the Holstein two-thirds of the total gain in height previous to parturition during the first year. Of the total weight at 24 months of age, Jerseys make two-thirds, Holsteins and Ayrshires one-half during the first year. The daily gain in weight during the second year is .6, 1.1, and .7, for the Jersey, Holstein and Ayrshire, respectively.

The data in this thesis is summarized in Chart 2 and Table 17 which represents the calculation of standard growth for the dairy heifers from birth to twenty-four months of age.

TABLE I.

PERCENTAGE OF TOTAL GAIN TO 30 MONTHS
OF AGE BY SIX MONTH PERIODS.

HEAVY FED JERSEYS

Period:	No. of	: Height : of : Animals:	: Depth : of : Chest:	: Width : of : Hooks:	: Length from : withers to: : Hooks	: Length : from Hooks : to Pins	:
1	: 2	: 41.14	: 38.19	: 31.69	: 41.51	: 33.46	:
2	: 4	: 30.85	: 25.13	: 27.62	: 29.52	: 30.31	:
3	: 4	: 17.55	: 16.58	: 18.60	: 17.53	: 16.14	:
4	: 4	: 4.78	: 13.32	: 13.95	: 6.83	: 20.08	:
5	: 7	: 5.69	: 6.78	: 8.14	: 4.61	: -----	:

LIGHT FED JERSEYS.

1	: 4	: 39.89	: 37.54	: 33.67	: 39.20	: 36.84	:
2	: 6	: 23.63	: 21.99	: 21.89	: 24.14	: 21.05	:
3	: 7	: 12.85	: 14.66	: 18.18	: 14.70	: 14.91	:
4	: 8	: 13.42	: 15.54	: 12.76	: 17.15	: 19.30	:
5	: 7	: 10.21	: 10.26	: 13.47	: 4.46	: 7.89	:

TABLE 2.

PERCENTAGE OF TOTAL GAIN TO 30 MONTHS
OF AGE BY SIX MONTH PERIODS.

HEAVY FED JERSEYS.

Period:	No. of	Height of Withers	Average of four Measurements
:	Animals:	%	%
1	2	41.14	36.21
2	4	30.85	28.15
3	4	17.55	17.21
4	4	4.78	13.55
5	7	5.69	4.88

LIGHT FED JERSEYS

1	4	39.89	36.81
2	6	23.63	22.27
3	7	12.85	15.61
4	8	13.42	16.19
5	7	10.21	9.01

TABLE 3.

BIRTH WEIGHT OF CALVES.

Breed	No.	Av. Wt	% of Dam's Weight	Av. Dam's Weight
Jersey	128	55.195	6.37	866.35
Holstein	79	90.025	7.99	1126.58
Ayrshire	23	69.957	7.43	942.87

TABLE 4.

BIRTH WEIGHT BY SEXES.

Breed	Sex	No.	Av. Wt.	% of Dam's Weight	Av. Dam's Weight
Jersey	Heifers	58	52.689	6.16	855.45
"	Bulls	70	57.271	6.54	875.39
Holstein	Heifers	39	86.590	7.72	1121.82
"	Bulls	40	93.375	8.26	1131.375
Ayrshire	Heifers	12	64.833	7.04	920.33
"	Bulls	11	75.545	7.81	967.45

TABLE 5.

INDIVIDUAL DAILY GROWTH OF CALVES.

Age	:	:	:	:	:	:	:
in	:	No. 219	No. 249	No. 214	No. 9	No. 41	No. 10
Days	:	:	:	:	:	:	:
Birth:	:	99.0	90.0	87.0	60.0	67.0	57.0
1	:	97.5	87.5	96.0	57.0	70.0	57.0
2	:	106.0	92.5	95.5	59.0	70.5	58.5
3	:	110.0	91.0	95.0	62.5	71.0	58.0
4	:	107.5	89.0	97.5	60.0	70.5	58.5
5	:	107.0	93.0	100.0	63.5	73.0	61.5
6	:	107.5	92.0	102.0	64.0	75.0	60.0
7	:	110.5	92.5	102.0	66.0	74.0	59.0
8	:	114.0	93.0	107.5	67.5	74.0	62.0
9	:	113.0	92.5	107.0	63.5	77.5	66.0
10	:	114.0	96.0	104.0	65.0	76.0	65.0
11	:	117.5	96.0	107.0	65.0	78.0	65.0
12	:	118.0	97.0	106.0	61.0	76.0	67.5
13	:	119.0	97.0	107.5	63.0	77.5	66.0
14	:	119.5	101.5	107.5	65.0	80.0	69.0
15	:	121.0	102.0	109.0	63.0	81.5	70.0
16	:	122.5	100.0	111.0	63.0	79.0	68.0
17	:	122.0	102.0	109.5	65.0	81.0	69.0
18	:	123.5	104.0	113.0	65.0	80.5	72.5
19	:	125.0	106.5	113.0	66.0	81.5	72.5
20	:	128.0	109.0	113.5	67.0	82.0	73.5
21	:	130.0	108.5	114.0	67.0	82.5	75.0
22	:	132.5	112.0	115.0	68.5	85.0	75.0
23	:	132.5	113.0	115.5	73.0	85.5	78.5
24	:	132.0	110.0	116.0	75.0	85.5	77.5
25	:	137.0	113.0	116.0	78.0	85.0	78.5
26	:	138.0		115.5	79.5	86.5	78.5
27	:	137.5	114.0	118.0	80.0	88.5	78.5
28	:	143.0	115.5	122.5	81.0	89.0	80.5
29	:	140.0	116.0	122.5	82.0	90.5	84.0
30	:	142.0	121.0	125.0	82.0	90.0	87.0
31	:	142.0	122.0	127.0	81.5	90.0	87.0
32	:	144.5	123.0	127.0	82.0	91.5	86.0
	:						

TABLE 5.

INDIVIDUAL DAILY GROWTH OF CALVES.

Age	:	:	:	:	:	:	:
in	:	No. 83	:	No. 102	:	No. 124	:
Days	:	:	:	:	:	Average	:
Birth:	:	:	:	:	:	Weight	:
	:	45.0	:	50.0	:	53.0	:
	:	:	:	:	:	67.55	:
1	:	44.0	:	52.0	:	53.0	:
2	:	45.0	:	51.0	:	50.5	:
3	:	46.0	:	52.5	:	53.0	:
4	:	48.0	:	52.5	:	55.0	:
5	:	49.0	:	54.5	:	56.0	:
6	:	49.5	:	56.0	:	57.5	:
7	:	49.0	:	56.0	:	58.0	:
8	:	50.0	:	56.0	:	59.5	:
9	:	51.0	:	55.0	:	61.0	:
10	:	49.5	:	56.0	:	61.0	:
11	:	49.5	:	57.5	:	61.0	:
12	:	50.0	:	57.0	:	59.0	:
13	:	50.0	:	58.0	:	63.0	:
14	:	52.0	:	57.0	:	62.5	:
15	:	50.0	:	55.0	:	65.0	:
16	:	57.0	:	54.0	:	65.0	:
17	:	52.5	:	56.0	:	63.0	:
18	:	53.0	:	57.0	:	65.0	:
19	:	55.0	:	57.5	:	64.5	:
20	:	55.0	:	58.0	:	66.0	:
21	:	57.0	:	59.0	:	66.0	:
22	:	56.5	:	62.0	:	68.5	:
23	:	58.5	:	61.0	:	68.0	:
24	:	57.5	:	62.5	:	67.5	:
25	:	59.0	:	65.0	:	70.0	:
26	:	59.5	:	67.5	:	71.5	:
27	:	60.0	:	68.0	:	73.0	:
28	:	61.5	:	70.0	:	73.0	:
29	:	62.0	:	69.0	:	74.0	:
30	:	63.5	:	71.0	:	77.0	:
31	:	64.0	:	70.5	:	79.0	:
32	:	64.5	:	71.0	:	77.5	:
	:	:	:	:	:	:	:

TABLE 6.

GROWTH OF CALVES THE FIRST MONTH
BY TEN DAY PERIODS.

: Increase in Weight During :				
No. of:	First :	Second :	Third :	First :
Calf :	Period :	Period :	Period :	Month :
	Lbs. :	Lbs. :	Lbs. :	Lbs. :
219 :	15 . :	14 :	14 :	43 :
249 :	6 :	13 :	12.5 :	31.5 :
214 :	17 :	9.5 :	11.5 :	38 :
9 :	5 :	2 :	15 :	22 :
41 :	9 :	6 :	8 :	23 :
101 :	8 :	8.5 :	13.5 :	30 :
83 :	4.5 :	5.5 :	8.5 :	18.5 :
102 :	6 :	2 :	13 :	21 :
124 :	8 :	5 :	11 :	24 :
Av.:	8.72:	7.28 :	11.89:	27.89 :

TABLE 7.

INDIVIDUAL GROWTH OF STATION HEIFERS.

JERSEYS

No. 61 - Born Nov. 5, 1911.

Measure- ments:	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Withers	119.0	119.5	119.5	120.0	120.5	120.0	121.0
Hooks	122.5	121.5	120.0	120.0	121.5	122.0	122.0
Weight	595.0	652.0	638.0	670.0	684.0	698.0	700.0

No. 83, Born Jan. 1, 1912.

Withers	121.0	119.0	118.5	120.5	121.5	123.0	:
Hooks	125.5	124.0	126.0	125.0	126.0	128.5	Calved:
Weight	647.0	729.0	732.0	774.0	800.0	813.0	:

No. 86, Born, July 8, 1912.

Withers	116.0	117.0	118.5	119.5	119.0	118.5	121.0
Hooks	122.0	121.0	124.5	123.5	125.5	124.5	125.5
Weight	605.0	625.0	648.0	667.0	684.0	681.0	722.0

No. 87, Born Sept. 9, 1912.

Withers	112.5	114.0	113.5	114.5	116.5	118.0	117.5
Hooks	116.5	119.0	118.0	117.0	118.0	119.0	119.0
Weight	530.0	536.0	553.0	562.0	575.0	592.0	623.0

No. 89, Born Nov. 12, 1912.

Withers	104.5	106.5	109.0	111.5	113.5	114.0	116.0
Hooks	109.0	109.5	114.0	115.5	118.0	117.5	119.0
Weight	474.0	503.0	523.0	541.0	549.0	584.0	578.0

No. 90, Born Dec. 19, 1912.

Withers	106.0	108.5	109.5	109.5	112.5	113.0	113.5
Hooks	109.0	111.5	112.5	112.5	118.0	118.0	117.0
Weight	415.0	454.0	477.0	497.0	512.0	546.0	561.0

TABLE 7 - Continued

<u>No. 91 - Born Jan. 27, 1913</u>							
Measure- ments :	Oct. :	Nov. :	Dec. :	Jan. :	Feb. :	Mar. :	Apr. :
Withers :	97.5 :	99.0 :	102.0 :	105.0 :	106.5 :	106.5 :	108.5 :
Hooks :	98.0 :	101.0 :	103.5 :	104.5 :	108.5 :	107.0 :	109.5 :
Weights :	293.0 :	336.0 :	359.0 :	389.0 :	411.0 :	435.0 :	454.0 :

<u>No. 93 - Born Mar. 14, 1913</u>							
Withers :	98.5 :	103.5 :	104.0 :	106.0 :	105.5 :	110.0 :	112.0 :
Hooks :	103.0 :	106.5 :	108.5 :	109.5 :	111.0 :	114.5 :	115.5 :
Weight :	311.0 :	355.0 :	373.0 :	393.0 :	420.0 :	434.0 :	445.0 :

<u>No. 95 - Born May 30, 1913.</u>							
Withers :	87.0 :	94.0 :	96.0 :	99.5 :	106.5 :	107.0 :	109.0 :
Hooks :	90.5 :	97.5 :	100.0 :	104.0 :	110.0 :	110.0 :	113.0 :
Weight :	195.0 :	249.0 :	284.0 :	321.0 :	366.0 :	395.0 :	406.0 :

<u>No. 96 - Born Aug. 2, 1913.</u>							
Withers :	74.5 :	82.5 :	87.0 :	93.0 :	99.0 :	100.0 :	105.5 :
Hooks :	77.5 :	85.5 :	89.5 :	97.0 :	104.0 :	104.0 :	108.5 :
Weight :	105.0 :	145.0 :	185.0 :	223.0 :	272.0 :	317.0 :	360.0 :

<u>No. 98 - Born Oct. 16, 1913.</u>							
Withers :	:	72.0 :	77.5 :	83.0 :	89.0 :	93.5 :	97.0 :
Hooks :	:	74.0 :	78.0 :	86.0 :	93.0 :	98.0 :	100.0 :
Weight :	:	87.0 :	118.0 :	158.0 :	206.0 :	251.0 :	298.0 :

<u>No. 100 - Born Dec. 30, 1913.</u>							
Withers :	:	:	:	67.0 :	70.0 :	72.0 :	77.0 :
Hooks :	:	:	:	70.0 :	72.0 :	76.0 :	78.5 :
Weight :	:	:	:	61.0 :	77.0 :	92.0 :	123.0 :

<u>No. 101 - Born Jan. 17, 1914.</u>							
Withers :	:	:	:	:	72.0 :	76.5 :	82.5 :
Hooks :	:	:	:	:	73.0 :	81.5 :	84.0 :
Weight :	:	:	:	:	86.0 :	111.0 :	152.0 :

TABLE 7 - Continued

HOLSTEINS.

No. 235 - Born Dec. 26, 1911

Measure- ments	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Withers	125.0	127.0	126.5	129.0	128.5	130.5	128.5
Hooks	130.5	131.0	130.5	134.5	133.0	134.0	131.5
Weight	818.0	872.0	906.0	955.0	996.0	1002.0	1016.0

No. 236 - Born Jan. 26, 1912.

Withers	119.0	122.0	123.0	123.0	123.5	124.0	127.0
Hooks	125.5	129.0	128.0	128.0	129.5	129.5	130.0
Weight	736.0	792.0	795.0	840.0	861.0	899.0	934.0

No. 237.- Born Feb. 5, 1912.

Withers	122.0	124.0	123.5	124.0	126.0	126.0	129.0
Hooks	126.0	129.0	128.0	130.5	130.5	131.5	131.5
Weight	697.0	763.0	756.0	774.0	811.0	868.0	873.0

No. 238 - Born Oct. 12, 1912.

Withers	112.0	115.0	116.0	118.0	119.5	122.5	121.5
Hooks	117.0	119.0	122.0	123.0	122.5	127.0	125.0
Weight	532.0	560.0	574.0	601.0	640.0	660.0	659.0

No. 239 - Born Oct. 27, 1912.

Withers	114.0	115.0	116.0	120.0	121.5	122.5	122.5
Hooks	119.0	119.0	122.0	126.0	126.0	127.5	128.5
Weight	567.0	583.0	600.0	628.0	648.0	690.0	717.0

No. 241 - Born July 5, 1913.

Withers	88.0	95.5	99.0	103.5	108.5	109.5	111.5
Hooks	92.5	100.0	103.5	107.5	113.0	114.5	114.5
Weight	216.0	274.0	315.0	368.0	415.0	462.0	482.0

TABLE 7 - Continued

No. 242 - Born Aug. 10, 1913.

Measure- ments :	Oct. :	Nov. :	Dec. :	Jan. :	Feb. :	Mar. :	Apr. :
Withers :	86.0	91.5	94.5	100.5	106.5	105.0	111.5
Hooks :	88.5	95.5	100.5	104.0	110.5	111.0	115.0
Weight :	164.0	223.0	261.0	316.0	371.0	429.0	444.0

No. 243 - Born Aug. 10, 1913.

Withers :	82.5	88.0	94.0	98.5	105.0	107.0	109.0
Hooks :	84.0	91.0	96.5	101.0	107.5	108.5	111.0
Weight :	171.0	231.0	273.0	321.0	370.0	422.0	437.0

No. 244 - Born Sept. 13, 1913.

Withers :	73.0	81.5	85.0	90.0	96.5	97.0	102.0
Hooks :	78.5	86.5	87.0	94.0	100.5	102.0	104.0
Weight :	117.0	147.0	176.0	218.0	261.0	307.0	354.0

No. 245 - Born Oct. 30, 1913.

Withers :		74.0	79.0	85.5	92.0	91.5	98.5
Hooks :		77.5	82.5	88.5	92.0	98.5	101.5
Weight :		102.0	131.0	173.0	226.0	272.0	319.0

No. 246 - Born Nov. 20, 1913.

Withers :			76.0	81.0	87.0	91.5	97.5
Hooks :			81.0	85.5	92.5	96.5	100.5
Weight :			113.0	150.0	201.0	247.0	301.0

No. 248 - Born Dec. 25, 1913.

Withers :				75.5	80.5	84.0	88.0
Hooks :				79.0	85.0	88.5	92.5
Weight :				114.0	149.0	197.0	251.0

No. 249 - Born

Withers :							
Hooks :							
Weight :						120.0	153.0

TABLE 7 - Continued

AYRSHIRES.

<u>No. 313 - Born Apr. 11, 1912.</u>								
Measure- ments :	Oct. :	Nov. :	Dec. :	Jan. :	Feb. :	Mar. :	Apr. :	:
Withers :	114.0	114.0	116.0	115.5	117.0	117.0	118.0	:
Hooks :	119.5	120.0	122.0	119.5	121.5	123.0	123.0	:
Weight :	574.0	634.0	641.0	621.0	640.0	668.0	687.0	:

<u>No. 314 - Born Feb. 16, 1913.</u>								
Withers :	92.0	95.0	99.0	100.5	104.0	104.0	104.0	:
Hooks :	96.5	98.0	101.5	103.0	107.0	107.5	107.0	:
Weight :	285.0	333.0	347.0	372.0	396.0	411.0	442.0	:

<u>No. 315 - Born May 8, 1913.</u>								
Withers :	86.5	93.0	96.5	102.0	103.0	103.5	105.5	:
Hooks :	93.5	99.5	102.5	107.0	111.0	109.0	113.0	:
Weight :	255.0	308.0	337.0	372.0	425.0	455.0	472.0	:

TABLE 8.

GROWTH OF STATION HEIFERS BY MONTHS.

AYRSHIRES

Age :		Height :	Height :				
in :No. of :	at :	at :	No. of :				
Mo. :Animals:	Withers:	Hooks :	Animals:	Weight :			
1 :	:	:	:	1 :	90.0 :		
2 :	:	:	:	1 :	119.0 :		
3 :	:	:	:	2 :	143.5 :		
4 :	:	:	:	2 :	182.0 :		
5 :	1 :	85.5 :	93.0 :	2 :	216.0 :		
6 :	1 :	92.0 :	98.5 :	2 :	267.5 :		
7 :	1 :	95.5 :	102.0 :	2 :	291.5 :		
8 :	2 :	96.5 :	101.0 :	2 :	321.0 :		
9 :	2 :	98.0 :	104.0 :	2 :	361.0 :		
10 :	2 :	101.3 :	105.3 :	2 :	406.0 :		
11 :	4 :	106.2 :	110.2 :	4 :	495.0 :		
12 :	1 :	104.0 :	107.0 :	1 :	396.0 :		
13 :	3 :	108.5 :	113.3 :	4 :	511.3 :		
14 :	1 :	104.0 :	107.0 :	2 :	455.5 :		
15 :	1 :	118.5 :	125.0 :	2 :	593.0 :		
16 :	:	:	:	1 :	537.0 :		
17 :	1 :	120.0 :	125.5 :	2 :	658.5 :		
18 :	1 :	114.0 :	119.5 :	1 :	572.0 :		
19 :	1 :	114.0 :	120.0 :	1 :	626.0 :		
20 :	1 :	116.0 :	122.0 :	1 :	630.0 :		
21 :	1 :	115.5 :	119.5 :	1 :	635.0 :		
22 :	1 :	117.0 :	121.5 :	1 :	640.0 :		
23 :	1 :	117.0 :	123.0 :	1 :	668.0 :		
24 :	1 :	118.0 :	123.0 :	1 :	687.0 :		
:	:	:	:	:	:		

TABLE 8.

GROWTH OF STATION HEIFERS BY MONTHS.

JERSEYS

Age	:		:	Height	:	Height	:		:		:
in	:	No. of	:	at	:	at	:	No. of	:		:
Mo.	:	Animals:	:	Withers:	:	Hooks	:	Animals:	:	Weight	:
1	:	4	:	70.1	:	72.1	:	6	:	76.3	:
2	:	4	:	75.1	:	77.9	:	7	:	104.6	:
3	:	5	:	80.7	:	83.4	:	5	:	144.1	:
4	:	2	:	86.7	:	90.3	:	5	:	174.8	:
5	:	3	:	91.0	:	95.2	:	6	:	223.2	:
6	:	3	:	96.0	:	100.0	:	7	:	263.6	:
7	:	3	:	98.5	:	103.0	:	6	:	297.2	:
8	:	3	:	103.2	:	106.5	:	6	:	334.8	:
9	:	4	:	103.9	:	107.0	:	6	:	378.3	:
10	:	4	:	105.0	:	108.0	:	6	:	405.2	:
11	:	5	:	106.4	:	109.9	:	7	:	447.1	:
12	:	6	:	110.1	:	113.0	:	8	:	509.3	:
13	:	5	:	109.8	:	113.1	:	6	:	501.2	:
14	:	6	:	112.9	:	117.4	:	7	:	565.6	:
15	:	3	:	112.7	:	117.2	:	6	:	555.7	:
16	:	4	:	114.5	:	118.5	:	4	:	582.0	:
17	:	3	:	116.3	:	119.3	:	4	:	574.0	:
18	:	2	:	118.2	:	121.5	:	4	:	558.8	:
19	:	2	:	118.8	:	121.3	:	3	:	592.7	:
20	:	1	:	119.0	:	125.5	:	4	:	617.0	:
21	:	1	:	118.5	:	124.5	:	3	:	639.0	:
22	:	3	:	120.8	:	123.8	:	4	:	652.5	:
23	:	3	:	120.5	:	123.8	:	3	:	719.0	:
24	:	4	:	120.4	:	123.3	:	4	:	722.5	:
25	:	3	:	121.2	:	124.2	:	3	:	774.0	:
26	:	3	:	123.3	:	125.5	:	3	:	813.6	:
27	:	2	:	121.7	:	125.0	:	2	:	748.5	:
28	:	1	:	120.0	:	122.0	:	1	:	698.0	:
29	:	1	:	121.0	:	122.0	:	1	:	700.0	:
	:		:		:		:		:		:

TABLE 8.

GROWTH OF STATION HEIFERS BY MONTHS.

HOLSTEINS

Age :		Height :	Height :			
in :	No. of :	at :	at :	No. of :		
Mo. :	Animals:	Withers:	Hooks :	Animals:	Weight :	
1 :	6 :	75.4 :	79.3 :	9 :	119.1 :	
2 :	7 :	81.7 :	85.5 :	8 :	150.5 :	
3 :	6 :	87.2 :	90.7 :	7 :	196.3 :	
4 :	7 :	92.4 :	96.2 :	7 :	246.9 :	
5 :	6 :	97.2 :	101.0 :	7 :	294.9 :	
6 :	5 :	101.9 :	105.5 :	5 :	342.4 :	
7 :	3 :	104.7 :	108.7 :	6 :	379.5 :	
8 :	3 :	109.2 :	112.8 :	5 :	417.6 :	
9 :	1 :	110.0 :	115.0 :	3 :	443.3 :	
10 :	1 :	112.0 :	115.0 :	3 :	479.0 :	
11 :	0 :			2 :	509.5 :	
12 :	2 :	113.3 :	118.2 :	2 :	548.5 :	
13 :	2 :	115.3 :	119.3 :	2 :	573.0 :	
14 :	2 :	116.3 :	122.5 :	2 :	590.0 :	
15 :	2 :	119.3 :	125.0 :	3 :	586.3 :	
16 :	2 :	120.8 :	124.8 :	4 :	621.7 :	
17 :	3 :	123.7 :	128.2 :	6 :	674.8 :	
18 :	2 :	122.0 :	126.8 :	5 :	665.6 :	
19 :	1 :	125.0 :	129.0 :	4 :	746.5 :	
20 :	2 :	124.3 :	127.0 :	4 :	817.5 :	
21 :	2 :	121.5 :	127.3 :	3 :	776.0 :	
22 :	5 :	123.8 :	128.7 :	5 :	925.4 :	
23 :	3 :	124.7 :	129.3 :	3 :	813.6 :	
24 :	4 :	124.9 :	129.5 :	4 :	839.3 :	
25 :	3 :	126.2 :	121.8 :	3 :	894.7 :	
26 :	3 :	127.2 :	131.3 :	3 :	922.7 :	
27 :	2 :	128.7 :	123.0 :	2 :	968.0 :	
28 :	1 :	128.5 :	131.5 :	1 :	1016.0 :	
:	:	:	:	:	:	:

TABLE IX.

PERCENTAGE INCREASE BY SIX MONTH PERIODS.

STATION HEIFERS.

Withers				
Period:	Jerseys	Holsteins	Ayrshires	
1st	36.86	35.15		
2d	14.69	11.18	13.04	
3d	7.36	7.68	9.61	
4th	1.86	2.38	3.51	

Weight				
Period:	Jerseys	Holsteins	Ayrshires	
1st	245.48	187.49	197.22	
2d	93.21	60.19	48.04	
3d	9.72	21.35	44.44	
4th	29.29	39.62	20.10	

TABLE 10.

PERCENTAGE INCREASE BY SIX MONTH PERIODS.

JERSEYS

	Heavy Fed Group			Light Fed Group.		
Period:	Av. Withers:	Weight		Av. Withers	Weight	
	and Hooks			and Hooks		
1st	33.30%	251.25	:	31.30%	230.56%	:
2d	17.97	71.97	:	13.12	47.74	:
3d	8.83	45.33	:	6.65	32.11	:
4th	1.02	13.58	:	5.93	21.83	:
5th	3.44	12.98	:	4.62	31.24	:
6th	2.88	23.12	:	2.06	14.46	:

HOLSTEINS

1st	35.40	234.02	:	25.91	159.92	:
2d	12.60	57.63	:	10.61	34.00	:
3d	5.90	35.16	:	7.95	39.38	:
4th	4.14	22.45	:	5.25	19.75	:
5th	2.03	12.03	:	2.62	18.95	:
6th	.74	10.72	:	1.89	23.21	:

AYRSHIRES

1st	35.50	223.81	:	36.03	262.66	:
2d	10.24	75.59	:	13.64	52.21	:
3d	8.60	23.95	:	9.20	30.19	:
4th	2.99	30.54	:	5.08	28.46	:
5th	4.37	16.98	:	3.41	21.44	:

TABLE 11.

LIGHT FED AYRSHIRES

Age	No.	Height	Height	No.	
in	of	at	at	of	
Months	Animals	Withers	Hooks	Animals	Weight
1	1	64.0	68.0	1	75.0
2	1	68.5	70.5	1	111.0
3	1	73.0	75.5	1	151.0
4	1	76.0	81.0	2	200.0
5	1	81.0	86.5	2	236.5
6	1	88.0	91.5	2	272.0
7	1	91.0	95.5	2	289.0
8	1	93.5	97.5	2	307.0
9	1	95.5	101.0	2	320.0
10	1	97.0	101.5	2	360.0
11	1	99.0	104.0	2	392.0
12	1	99.5	104.5	2	414.0
13	1	101.0	105.5	2	447.0
14	1	102.5	108.2	2	479.0
15	1	104.2	108.5	2	491.0
16	1	105.5	109.7	2	505.0
17	1	107.0	111.0	2	514.0
18	2	107.9	114.9	2	541.0
19	1	109.5	114.3	2	549.0
20	1	110.2	115.0	2	577.0
21	2	111.2	117.0	2	627.0
22	2	113.0	117.4	2	645.0
23	2	113.9	119.0	2	659.0
24	1	115.0	119.0	2	695.0
25	2	114.7	121.5	2	721.0
26	2	115.6	121.2	2	749.0
27	1	118.0	122.5	1	805.0
28	1	118.5	123.5	1	844.0

TABLE 11.

HEAVY FED AYRSHIRES

Age in Months	No. of Animals	Height at Withers	Height at Hooks	No. of Animals	Weight
1	1	71.5	76.5	2	105.0
2	1	77.0	80.0	2	150.0
3	1	82.5	88.0	2	194.0
4	1	89.5	93.0	2	254.0
5	1	94.5	98.0	2	307.0
6	1	97.5	103.0	2	340.0
7	1	101.0	105.5	2	379.0
8	1	102.0	109.0	2	414.0
9	1	104.0	109.5	2	456.0
10	1	104.5	114.2	2	517.0
11	1	105.5	112.0	2	551.0
12	1	108.0	113.0	2	597.0
13	1	109.2	115.0	2	622.0
14	1	110.5	116.5	2	651.0
15				2	684.0
16	1	112.0	117.0	2	693.0
17	1	115.5	119.5	2	714.0
18	2	117.5	122.5	2	740.0
19	2	119.0	124.0	2	791.0
20	2	118.2	125.0	2	824.0
21	2	119.5	125.7	2	836.0
22	2	120.2	126.7	2	877.0
23	2	120.6	126.7	2	920.0
24	2	120.5	126.7	2	966.0
25	1	125.0	132.0	2	1000.0
26	1	125.5	131.5	1	1102.0
27	1	125.5	132.5	1	1130.0

TABLE 11.

LIGHT FED HOLSTEINS

Age	No.	Height	Height	No.	
in	of	at	at	of	
Months	Animals	Withers	Hooks	Animals	Weight
1	4	76.7	80.5	7	124.0
2	4	82.4	85.4	7	158.4
3	4	85.9	89.6	7	194.6
4	4	91.0	94.9	8	234.4
5	4	95.0	98.2	8	273.2
6	5	97.1	100.8	7	322.3
7	7	99.3	103.2	8	334.6
8	5	100.0	103.9	8	347.9
9	6	101.8	105.7	8	376.0
10	6	103.5	109.1	8	395.8
11	7	105.8	110.1	8	413.0
12	7	107.5	111.4	8	431.9
13	5	110.0	114.0	8	457.6
14	7	110.6	115.0	8	484.1
15	7	111.7	115.7	8	507.9
16	7	113.4	117.7	8	537.4
17	7	114.8	119.0	8	569.2
18	7	116.1	120.2	8	602.0
19	7	117.3	121.5	8	621.0
20	6	117.8	122.1	8	645.6
21	7	118.0	123.5	8	673.0
22	8	120.7	125.0	8	701.4
23	5	123.0	127.1	8	719.7
24	7	122.2	126.5	7	720.9
25	7	123.9	127.6	7	758.7
26	5	124.0	128.7	7	776.0
27	7	124.1	128.4	7	801.6
28	6	125.4	129.2	7	821.0
29	7	125.4	129.7	7	846.4
30	6	125.8	129.9	6	857.5
31	5	127.2	130.9	5	891.4
32	4	128.1	130.9	5	937.4
33	5	127.6	132.0	5	952.8
34	3	127.9	131.8	3	988.3
35	3	128.6	131.5	2	1047.0
36	2		131.9	2	1056.5

TABLE 11.

HEAVY FED HOLSTEINS

Age in Months	No. of Animals	Height at Withers	Height at Hooks	No. of Animals	Weight
1	4	77.4	80.7	8	126.4
2	4	83.2	88.0	8	169.6
3	4	88.9	91.2	8	224.4
4	4	96.0	98.0	8	285.6
5	4	100.4	103.7	8	358.0
6	7	105.0	109.2	8	422.2
7	6	106.0	110.8	8	454.1
8	6	108.8	113.9	8	497.4
9	7	112.0	117.1	8	543.0
10	7	114.2	118.9	8	594.3
11	7	116.0	121.5	8	627.5
12	7	118.3	123.1	8	665.5
13	7	119.4	124.7	8	713.6
14	7	120.7	125.7	8	739.1
15	7	122.5	127.1	8	782.1
16	6	124.0	128.6	8	824.1
17	7	125.0	129.4	8	858.6
18	8	126.2	129.4	8	899.5
19	7	127.0	130.9	8	937.7
20	7	128.7	131.0	7	973.6
21	6	128.0	131.1	7	1006.3
22	4	130.3	133.7	5	1056.8
23	4	130.3	134.1	4	1065.0
24	4	131.2	135.0	4	1101.5
25	4	131.7	134.8	4	1123.5
26	4	132.6	135.5	4	1147.0
27	4	133.1	135.8	4	1172.0
28	3	135.1	137.1	4	1174.2
29	3	134.8	136.9	4	1196.0
30	4	133.9	137.5	4	1234.0
31	4	134.2	136.3	4	1275.0
32	4	134.8	137.8	4	1327.7
33	2	134.5	136.7	3	1366.3
34	2	135.7	137.7		

TABLE 11.

LIGHT FED JERSEYS

Age in Months	No. of Animals	Height at Withers	Height at Hooks	No of Animals	Weight
1	4	70.0	72.5	11	79.2
2	4	74.5	79.0	12	121.0
3	4	79.1	82.6	12	155.7
4	4	83.5	88.3	12	188.7
5	4	86.6	91.1	12	225.2
6	6	91.1	95.1	12	251.8
7	5	93.9	97.9	12	272.7
8	5	95.2	99.0	12	289.3
9	5	97.0	101.3	12	303.8
10	6	99.0	102.7	12	331.5
11	5	101.3	105.0	11	351.7
12	7	103.6	107.0	12	372.0
13	7	104.5	109.0	12	392.8
14	6	105.6	110.3	12	421.9
15	6	106.2	111.0	12	442.3
16	6	108.0	113.0	12	464.9
17	6	109.0	114.0	12	482.9
18	8	110.4	114.2	12	498.9
19	9	111.8	114.8	10	524.9
20	10	112.5	116.2	10	539.0
21	8	114.0	117.7	10	564.8
22	10	113.9	118.8	9	583.2
23	10	115.7	119.3	9	607.3
24	7	117.5	120.4	6	607.8
25	7	117.4	123.5	6	632.3
26	5	119.3	123.0	4	685.0
27	5	119.3	123.6	4	715.0
28	5	120.3	124.3	4	740.2
29	5	121.7	125.0	4	778.2
30	5	122.9	126.0	4	797.7
31	5	122.2	126.4	4	822.0
32	5	123.1	127.6	4	837.5
33	4	125.3	127.8	3	883.3
34	3	125.0	125.7	2	882.0
35	2	126.5	127.5	1	915.0

TABLE 11.

HEAVY FED JERSEYS

Age	No.	Height	Height	No.	
in	of	at	at	of	
Months	Animals	Withers	Hooks	Animals	Weight
1	2	68.7	72.5	7	84.1
2	3	75.9	79.1	8	124.6
3	3	79.6	82.2	8	167.7
4	3	83.5	87.9	9	221.1
5	3	90.0	94.5	9	266.7
6	4	91.9	96.3	9	295.4
7	4	96.5	100.9	9	335.4
8	4	99.6	103.9	9	366.1
9	4	103.4	107.1	9	400.4
10	4	104.9	109.1	9	437.2
11	4	107.5	109.5	9	480.5
12	4	109.3	112.7	9	508.0
13	4	110.9	114.0	9	548.2
14	4	112.2	115.9	9	583.0
15	4	114.0	117.3	9	617.2
16	3	113.5	116.5	9	655.5
17	4	116.0	119.2	9	701.4
18	4	119.2	122.4	9	738.3
19	5	118.3	121.9	7	745.5
20	3	119.6	121.4	7	781.0
21	4	120.9	124.0	7	783.0
22	3	121.3	123.6	6	791.3
23	5	121.3	122.3	5	810.8
24	5	121.9	122.1	5	838.2
25	5	123.2	125.3	5	852.2
26	4	124.0	125.8	5	867.2
27	5	124.4	126.1	5	886.0
28	4	125.1	127.9	5	912.0
29	5	124.4	126.6	5	934.0
30	5	125.1	127.3	5	947.0
31	5	125.0	128.0	5	968.4
32	5	125.2	127.4	4	1019.7
33	4	126.2	127.3	4	1053.7
34	4	126.5	128.2	3	1119.0
35	4	127.0	132.7	2	1166.0

TABLE 12.

WEIGHT OF HOLSTEIN HEIFERS AT MICHIGAN STATION.

Age in:		No. of		Weight		
Months:	Animals	Average	Lowest	Highest		
Birth	7	96.43	86	107		
3	7	229.14	200	293		
6	7	409.90	345	517		
9	7	563.90	501	697		
12	7	706.00	625	850		

TABLE 13 .

GROWTH OF CALVES AT NEW YORK - CORNELL - STATION.

Months	Holsteins			Jerseys		
	No. of			No. of		
	Animals	Weight		Animals	Weight	
Birth	12	81.7	:	5	50.4	:
1st	2	104.0	:	-	----	:
2d	3	157.7	:	2	138.5	:
3d	2	193.0	:	-	-----	:
4th	2	243.0	:	-	----	:
5th	2	306.0	:	-	----	:
6th	1	424.0	:	2	328.0	:

TABLE 14.**GUERNSEYS**

Age in:		No. of	Height at Withers			Height at Hooks		
Months:	Animals:		Lowest:	Highest:	Average:	Lowest:	Highest:	Average:
1	2		72.0	73.5	72.7	75.0	76.0	75.5
2								
3	3		81.0	89.0	84.3	86.0	91.0	88.2
4								
5								
6	6		90.5	99.5	96.7	93.0	104.0	100.2
7	6		94.5	104.0	100.5	98.5	107.5	104.5
8	3		102.5	105.0	103.6	104.0	108.5	106.6
9	2		105.5	106.5	106.0	108.0	108.5	108.2
10	7		100.5	113.0	105.2	105.0	118.0	109.1
11	3		103.0	111.5	107.0	106.5	115.5	111.0
12	6		107.5	115.5	110.8	111.5	120.0	114.3
13	5		109.0	119.0	112.7	111.5	125.0	116.7
14	6		109.5	117.0	113.1	112.5	121.5	117.1
15	4		112.0	119.5	116.1	116.5	124.0	120.4
16	1				115.0			120.0
17	3		112.0	117.0	114.1	115.0	119.5	117.1
18	1				119.0			123.5
19	2		116.0	121.5	118.7	120.0	126.0	123.0
20	4		118.0	121.5	119.6	120.5	123.0	121.7
21	2		112.5	123.5	118.0	115.5	125.0	120.2
22	3		117.5	121.5	119.3	118.0	122.0	120.3
23	2		120.0	120.0	120.0	121.0	122.0	121.5
24	1				125.5			129.5
25	4		119.5	124.0	120.8	120.0	126.0	122.4

TABLE 14.

AYRSHIRE

Age in:	No. of:	Height at Withers			Height at Hooks		
Months:	Animals:	Lowest:	Highest:	Average:	Lowest:	Highest:	Average:
1							
2							
3							
4							
5							
6							
7	1			93.0			98.0
8	1			101.0			104.5
9	4	103.0	107.5	105.5	107.5	111.5	108.6
10							
11	3	108.5	114.5	112.3	114.0	118.0	116.3
12	1			113.0			116.0
13							
14	3	110.0	117.5	112.8	114.0	118.5	115.8
15							
16							
17							
18	2	121.5	128.5	125.0	124.5	131.0	127.7
19							
20	2	118.5	119.5	119.0	119.5	121.0	120.2
21	1			119.5			121.5
22							
23	1			121.5			125.5
24	2	124.5	126.5	125.5	125.5	129.0	127.2
25							
26	1			125.0			126.0
36	1			126.0			128.0

TABLE 14.

HOLSTEINS

Age in:	No. of	Height at Withers			Height at Hooks		
Months:	Animals:	Lowest:	Highest:	Average:	Lowest:	Highest:	Average:
1							
2							
3							
4							
5							
6	2	104.0	112.0	108.0	106.5	117.0	111.7
7	5	106.5	111.5	108.7	111.0	116.0	113.2
8	6	108.5	115.5	112.5	112.0	121.0	116.0
9	10	110.0	120.0	113.4	112.0	125.0	116.7
10	6	109.5	118.0	114.6	112.0	122.0	117.4
11	3	115.5	125.0	118.8	120.5	126.5	123.3
12	6	116.0	121.0	119.6	121.0	127.0	124.1
13	4	122.0	130.5	125.1	125.5	130.5	128.4
14	3	122.0	123.5	122.5	126.5	127.0	126.9
15	3	121.5	127.5	124.8	126.0	129.5	128.1
16							
17	1			127.5			133.0
18	3	130.0	132.5	131.1	131.5	136.0	134.1
19	2	124.5	127.5	126.0	129.5	130.5	130.0
20	3	126.0	138.0	131.3	129.0	138.5	134.0
21	2	126.0	129.0	127.5	128.0	133.0	130.5
22	3	130.0	133.0	131.0	131.0	137.5	134.5
23	2	128.5	132.0	130.2	131.0	135.5	133.2
24	2	127.0	136.0	131.5	131.5	139.5	135.5
25	2	132.0	134.5	133.2	133.0	134.5	133.7
26	3	132.5	137.0	135.0	133.0	138.0	135.6

TABLE 14.

JERSEYS

Age in Months	No. of Animals	Height at Withers			Height at HOOKS		
		Lowest	Highest	Average	Lowest	Highest	Average
1							
2	1			74.5			76.0
3							
4	1			90.0			91.0
5	8	83.0	93.5	87.5	86.5	97.0	90.6
6	15	87.5	94.5	90.6	90.5	98.0	94.0
7	16	88.5	104.5	94.4	93.0	109.5	98.2
8	7	90.5	98.0	95.0	93.0	103.0	99.0
9	9	92.5	107.5	100.4	94.5	109.5	102.6
10	6	97.5	105.5	102.2	101.0	107.0	105.3
11	2	103.5	104.0	103.7	106.0	108.0	107.0
12	3	100.5	114.0	106.2	102.5	119.0	109.3
13	1			107.0			109.5
14	6	102.0	111.5	107.2	107.0	114.0	110.1
15	3	97.0	122.5	108.3	100.0	123.5	110.1
16	3	100.5	111.0	106.7	104.5	112.5	108.8
17	3	97.0	112.5	106.8	101.5	113.0	109.2
18	2	116.0	121.5	118.7	117.5	124.0	120.7
19	6	108.0	123.0	113.9	110.0	123.0	115.2
20	2	114.0	114.0	114.0	115.0	117.0	116.0
21	2	102.0	121.0	111.5	104.0	125.5	114.7
22	1			112.5			113.0
23							
24	3	114.5	123.0	118.5	115.5	123.5	120.6

TABLE 15.

UNACCOUNTABLE FLUCTUATION IN MEASUREMENTS.

Months	: Height : at : Withers	: Height : at : Hooks	: : :	Weight	: : :
May*	: **	:	:	496	:
June	:	:	:	553	:
July	:	:	:	554	:
Aug.	:	:	:	576	:
Sept.	:	:	:	621	:
Oct.	: 119	: 122.5	:	595	:
Nov.	: 118.5	: 120.5	:	652	:
Dec.	: 119.5	: 120.0	:	638	:
Jan.	: 120.0	: 120.0	:	672	:
Feb.	: 120.5	: 121.5	:	684	:
Mar.	: 120.0	: 122.0	:	698	:
Apr.	:	:	:		:

* 18th month.

** Measurements were not begun until Oct.

TABLE 16.

MONTHLY INCREASE IN MEASUREMENTS.JERSEY

Month:	Station Heifers		Heavy Fed		Light Fed.	
	Withers:	Weight	Withers	Weight	Withers	Weight
2	5.0	28.3	7.2	40.5	4.5	41.8
3	5.0	39.5	3.7	43.1	4.6	32.7
4	6.0	30.7	3.9	53.4	4.4	35.0
5	4.3	48.4	6.5	45.6	3.1	36.5
6	5.0	40.4	1.9	28.7	4.5	26.6
7	2.5	33.6	4.6	40.0	2.8	20.9
8	4.7	37.6	2.9	30.7	1.3	16.6
9	.7	33.5	3.8	34.3	1.8	14.5
10	1.1	26.9	1.5	36.8	2.0	27.7
11	1.4	41.9	2.6	43.3	2.3	20.2
12	3.7	62.2	1.8	27.5	2.3	20.3
13	-.3	- 8.1	1.6	40.2	.9	20.8
14	3.1	64.4	1.3	34.8	1.1	29.1
15	-.2	- 9.9	1.8	34.2	.6	20.4
16	1.8	26.3	-.5	38.3	1.8	22.6
17	1.8	- 8.0	2.5	45.9	1.0	18.0
18	1.9	-15.2	3.2	37.9	1.4	16.0
19	.6	33.9	-.9	7.2	1.4	26.0
20	.2	24.3	1.3	35.5	.7	14.1
21	-.5	22.0	1.3	2.0	1.5	25.8
22	2.3	13.5	.4	8.3	-.1	18.4
23	-.3	66.5	.0	19.5	1.3	24.1
24	-.1	3.5	.6	27.4	1.8	.5
25	.8	51.5	1.3	14.0	-.1	24.5
26	2.1	39.6	.8	15.0	1.9	52.7
27	-1.6	-65.1	.4	18.8	.0	30.0
28	-1.7	-50.5	.7	26.0	1.0	25.2
29	1.0	2.0	-.7	22.0	1.4	38.0
30			.7	13.0	1.2	19.5
31			-.1	21.4	-.7	24.3
32			.2	50.3	.9	15.5
33			1.0	34.0	2.2	45.8

- Denotes a decrease.

TABLE 16.

MONTHLY INCREASE IN MEASUREMENTS.

HOLSTEINS

Month:	Station Heifers:		Heavy Fed		Light Fed	
:	Withers:	Weight	Withers :	Weight	Withers :	Weight:
2 :	6.3 :	31.4 :	5.8 :	43.2 :	5.7 :	34.4 :
3 :	5.5 :	45.8 :	5.7 :	54.8 :	3.5 :	36.2 :
4 :	5.2 :	50.6 :	7.1 :	61.2 :	5.1 :	39.8 :
5 :	4.8 :	48.0 :	4.4 :	72.4 :	4.0 :	38.8 :
6 :	4.7 :	47.5 :	4.6 :	64.2 :	2.1 :	49.1 :
7 :	2.8 :	37.1 :	1.0 :	31.9 :	2.2 :	12.3 :
8 :	4.5 :	38.1 :	2.8 :	43.3 :	.7 :	13.3 :
9 :	.8 :	25.7 :	3.2 :	45.6 :	1.8 :	28.1 :
10 :	2.0 :	35.7 :	2.2 :	51.3 :	1.7 :	17.8 :
11 :	:	30.5 :	1.8 :	33.3 :	2.3 :	19.2 :
12 :	:	39.0 :	2.3 :	37.9 :	1.7 :	18.9 :
13 :	2.0 :	24.5 :	1.1 :	48.1 :	2.5 :	25.7 :
14 :	1.0 :	17.0 :	1.3 :	25.5 :	.6 :	26.5 :
15 :	3.0 :	- 3.7 :	1.8 :	43.1 :	1.1 :	23.8 :
16 :	1.5 :	35.4 :	1.5 :	42.0 :	1.7 :	29.5 :
17 :	2.9 :	53.1 :	1.0 :	34.5 :	1.4 :	31.8 :
18 :	-1.7 :	- 9.2 :	1.2 :	40.9 :	1.3 :	32.8 :
19 :	3.0 :	80.9 :	.8 :	38.2 :	1.2 :	19.0 :
20 :	- .7 :	71.0 :	1.7 :	35.9 :	.5 :	24.6 :
21 :	-2.8 :	-41.5 :	- .7 :	32.7 :	.2 :	27.4 :
22 :	2.3 :	149.4 :	2.3 :	50.5 :	2.7 :	28.4 :
23 :	.9 :	-111.8 :	.0 :	8.2 :	.3 :	18.3 :
24 :	.2 :	125.7 :	.9 :	36.5 :	- .8 :	1.2 :
25 :	1.3 :	- 44.6 :	.5 :	22.0 :	1.7 :	37.8 :
26 :	1.0 :	28.0 :	.9 :	23.5 :	.1 :	17.3 :
27 :	1.5 :	45.3 :	.5 :	25.0 :	.1 :	25.6 :
28 :	- .2 :	48.0 :	2.0 :	2.2 :	1.3 :	19.4 :
29 :	:	:	- .3 :	21.8 :	.0 :	25.4 :
30 :	:	:	- .9 :	38.0 :	.4 :	11.1 :
31 :	L	:	.3 :	41.0 :	1.4 :	33.9 :
32 :	:	:	.6 :	38.6 :	.9 :	46.0 :
33 :	:	:	- .3 :	-27.8 :	- .5 :	15.4 :

- Denotes a decrease.

TABLE 17.

STANDARD GROWTH.

Age in Months	Ayrshires		Jerseys		Holstein	
	Withers	Weight	Withers	Weight	Withers	Weight
1	68.0	90	70.0	80	76.5	123
2	73.5	130	75.2	116	82.4	155
3	79.0	173	80.6	156	87.3	203
4	84.5	210	86.2	195	92.3	250
5	88.5	248	90.3	235	97.3	298
6	92.5	287	94.5	265	102.0	350
7	96.0	318	97.8	297	104.8	380
8	98.3	348	101.0	334	106.6	416
9	100.5	378	103.0	378	108.6	444
10	102.5	409	105.0	405	110.5	480
11	104.5	440	106.9	439	112.3	513
12	106.5	470	108.5	468	114.0	548
13	108.0	500	110.0	498	115.8	574
14	109.5	525	111.5	527	117.2	596
15	111.0	550	113.0	556	118.5	620
16	112.0	570	114.8	570	119.8	648
17	113.0	590	116.1	584	121.0	675
18	114.0	610	117.4	598	122.0	710
19	115.0	632	118.2	615	122.5	746
20	116.0	654	119.0	632	123.0	788
21	117.0	680	119.5	650	123.5	820
22	118.0	702	120.0	675	124.0	845
23	119.0	726	120.5	700	124.5	870
24	120.0	750	121.0	730	125.0	900

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Chart I

Height
in cm

Wither Heights on
Ayrshire Heifers

- Normal
- Light Fed
- Heavy Fed
- Exhibition

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Age in months

Height
in cm.

Chart I

Wither Heights on
Holstein Heifers

- Normal
- Light Fed
- Heavy Fed
- Exhibition

Height
in Cm.

Chart I

Wither Heights on

Jersey Heifers

— Normal

— Light Fed

— Heavy Fed

— Exhibition

Age in
Months

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35

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PLATE B—FOR SALE BY THE UNIVERSITY CO-OPERATIVE STORE, COLUMBIA, MO.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

135

130

125

120

115

110

105

100

95

90

85

80

75

70

65

Chart II

Standard Wither Heights to 24 mo.

Height
in cm.

130

125

120

115

110

105

100

95

90

85

80

75

70

65

— Holsteins
— Jerseys
— Ayrshires

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 1

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PLATE B — FOR SALE BY THE UNIVERSITY CO-OPERATIVE STORE, COLUMBIA, MO.

Age in Mo

Breeders Whose Dairy Heifers Furnished
The Data on Exhibition Animals
Presented in this Thesis

AYRSHIRE BREEDERS

R. R. Ness, Howick, Quebec, Canada.
Adam Seitz, Waukesha, Wisconsin.
W. P. Schanck, Avon, New York.

GUERNSEY BREEDERS

E. H. Baker, Gates Mill, Ohio.
T. W. Brophy, Edison Park, Illinois.
Consumers Company, Chicago, Illinois.
A. W. & F. E. Fox, Waukesha, Wisconsin.
Maple Farm of Midlothian, Tinley Park, Ill.,
W. W. Marsh, Waterloo, Iowa.
F. G. Thompson, Devon, Pennsylvania.
Upland Farms, Ipswich, Mass.
Edward A. Walters, Walworth, Wisconsin.
Wiscinda Stock & Dairy Farm, Acton, Indiana.
Wilcox & Stubbs, Des Moines, Iowa.
Westmoreland Farms, Oconomowoc, Wisconsin.
John H. Williams, Waukesha, Wisconsin.

HOLSTEIN BREEDERS.

Geo. M. Carpenter, Wilkes Barre, Pa.,
Geo. J. C. Copestake, Ames, Iowa.
W. M. Downing & Bro., Waukesha, Wisconsin.
M. R. Evans, Hinckley, Illinois.
Wm. Everson & Son, Lake Mills, Wisconsin.
R. E. Haeger, Algonquin, Illinois.
Iowana Farms, Davenport, Iowa.
E. C. Schroeder, Moorehead, Minnesota.
Traverse City State Hospital, Traverse City, Mich.
Frank White & Son, Woodstock, Illinois.
C. A. Nelson, Waverly, Iowa.
E. C. Barrick, Jonesville, Iowa.
W. B. Loveland, Jonesville, Iowa.
McKay Brothers, Waterloo, Iowa.

JERSEY BREEDERS

John F. Boyd, Rushville, Indiana.
W. S. Dixon, Brandon, Wisconsin.
C. H. Dewey, Morris, Illinois.
J. K. Dering, Lake Villa, Illinois.
Elmendorf Farms, Lexington, Kentucky.
Nelle Fabyan, Geneva, Illinois.
Jersey Isle Stock Farm, Rushville, Indiana.
Kington Brothers, Avon, Illinois.
Ed. C. Lasater, Falfurrias, Texas.

Jersey Breeders (Continued)

Geo. T. Slade, White Bear Lake, Minnesota.

John B. Stump, Monmouth, Oregon.

Henry Webster & Son, Minneapolis, Minnesota.

Whitacre & Son, West Liberty, Iowa.

Shoemaker, Maine, Van Pelt Co., Waterloo, Iowa.

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~~This thesis is never to leave this room.~~
~~Neither is it to be checked out overnight.~~