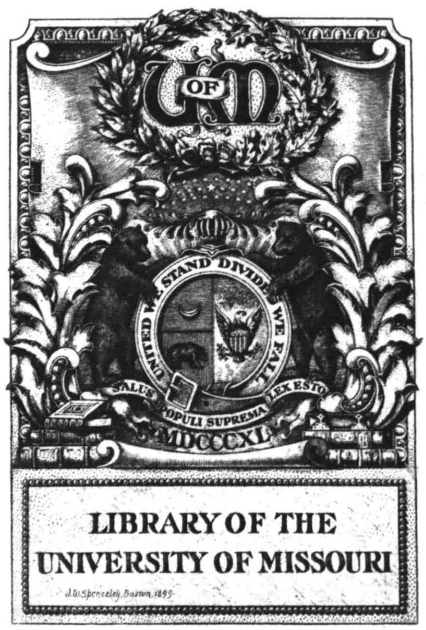
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Approved, H. O. Allison
May 15, 1916

THE EFFECTS OF VARIOUS PLANES OF NUTRITION UPON THE COST OF MAINTENANCE, REPRODUCTION, AND DEVELOPMENT OF BEEF COWS

by

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INTRODUCTION.

The frequency with which valuable animals reproduce themselves has always been a factor of economic importance in the pure bred cattle business. Great economic changes during the last few years havemade this an important factor in the grade cattle business as well. When the cost of maintaining a cow for a year was far less and the value of the calf not nearly so great, the annual percentage of calves produced by a herd of grade cows was not a matter of so much importance. The dry cows would fatten, and often the difference in value between a fat dry cow and a cow with calf at side was not great. At present, with higher maintenance cost and greater calf values, the calf crop percentage is one of the most important factors in determining the financial returns from a herd of grade cows. It was with the view of studying the effects of nutrition upon reproduction that this work was undertaken.

A part of the literature included in the review

refers to other factors than feed, or to other species of animals than cattle. In including these references it is the opinion of the writer that any factors affecting reproduction in general are of interest. It is not assumed that factors which affect the reproductive properties of one species of animals will affect cows to a similar degree. In fact, it appears from the literature quoted that external factors exert a less marked influence upon reproduction in cattle than in some other species.

The experiment was planned and directed by Professor H. O. Allison of the Department of Animal Husbandry. It has been the work of the writer to compile the data which is included in this paper.

REVIEW OF LITERATURE.

OESTRUM.

According to Marshall[1] and Marshal and Jolly[2], oestrum is caused by a secretion of the ovaries. They base their conclusions upon the fact that complete ovariotomy is followed by cessation of oestrum; that other investigators have shown that severing or removing a section of the spinal cord in the lumbar region of the bitch did not seem to interfere with oestrum; thus showing that there is no direct connection between the nervous system and the occurrence of "heat"; that in animals in which ovariotomy has been followed by cessation of oestrum a successful ovarian graft is followed by the reoccurrence of oestrum; and that their experiments have shown that injections into a female of ovarian extract from a female in "heat" has been followed by all of the indications of oestrum. These authors state that this secretory activity of the ovaries can be influenced to some extent by the climate, nature and amount of food, and the general environmental conditions.

Many authors have called attention to the effect of domestication and captivity on the breeding habits of

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1. Physiology of Reproduction, Chapt. IX.
2. Trans. of the Royal Soc. Vol. 198, Sec. B, pp 99 - 141.

animals, and although some species in captivity become sterile, domestication as a rule increases the frequency of breeding as well as the number born per litter. Marshall[1] has discussed the matter, and Heape[2] also has written quite a detailed account of the same. According to the latter writer, the breeding habits, and consequently the period of oestrum in animals is influenced by climatic conditions, under which head are included the nature and variations of the seasons and the amount and quality of the food supply; also by individual influences which are "special nervous vascular and secretory peculiarities of the individual and its habits of life," and lastly by maternal influences; that is, gestation and lactation and the mother's powers of recuperation from the same. His observations and studies would indicate that an abundant food supply and favorable climate tend to increase the frequency of breeding among animals.

Marshall and Jolly cited above say, "The periodicity of oestrum in certain of these animals (larger carnivora) in the Gardens at Dublin is said to be markedly affected by accommodation, heat, and feeding, and can to a certain extent at any rate be regulated."

It is the opinion of range men in the western sections of this country that during the year following

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1. Physiology of Reproduction, Chapts. I. and II.
2. Journal of Micro. Sc. Vol. 44, pp 1 - 70.

a dry summer, the percentage of cows dropping calves is considerably lower than usual. They do not attribute this to any influence which might affect the chances of the cow to conceive when bred, but explain it on the basis that insufficient food supply is unfavorable for the frequent and regular occurrence of heat in cows, and hence their failure to get with calf.

Hart, McCullum and Steenbock[1], studying the effects on reproduction of rations of the same nutritive ratio but selected from restricted sources, fed one lot of cows on a ration selected entirely from the corn plant and its products, another on the oats plant, a third on the wheat plant, and still another on a mixture selected from the three plants. They state that while there was more or less variation between individuals of the same lots, that as a rule the corn fed cows came in heat from four to six weeks after calving, but that in the wheat fed group oestrum as a rule did not occur until ten to eighteen weeks after calving.

Hart, McCullum and Humphrey[2] have reported that varying the amount of ash constituents in a ration fed to a cow did not cause any disturbance of the oestrum periods.

Discussing the effect of flushing ewes,

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1. Wis. Research Bulletin No. 17.
2. Wis. Research Bulletin No. 5.

Marshall[1] has stated, "There is abundant evidence also that flushing tends to hasten the time of the breeding season."

Shaw and Heller[2] state that having the ewes in a flourishing condition also shortens the mating season.

Craig[3] tried to hasten the mating season of a flock of ewes by flushing them during the summer but was unsuccessful. Stabling the flock in a barn in which the temperature had been lowered also seemed to have no effect.

Shaw[4] noticed the following phenomenon in the breeding habits of sheep; that as a general rule ewes which had suckled a winter lamb would breed soon after the lamb was weaned if they were fed a liberal grain ration in a dry lot, but if they were turned on grass they generally would not breed immediately, even if the grain ration was continued.

It appears, that the food supply and the general environmental conditions affect the oestrum periods of animals to a very marked degree, and that an insufficient supply of food tends to disturb the regularity of their occurrence.

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1. Science Progress, Vol. 2, pp 369 - 377.
2. U.S.Dept. Agrl. Bulletin No. 20.
3. Wis. Report 1894, pp 42 - 51.
4. Minn. Bulletin No. 78.

CONCEPTION.

The majority of stockmen believe that extreme high condition is frequently the cause of barrenness. A census of the breeding records of the prize winning females at the leading stock shows would possibly present some very interesting information on this question.

Marshall[1] has called attention to the large number of barren mares which appear at the agricultural shows in England. He also says, "Some foods are said to induce sterility more easily than others. Sugar, molasses, and linseed are noted for having this effect when given to cattle."

Davenport[2] says, "Excessive feeding of animals, especially females, tends to fatty degeneration of the essential sexual organs and consequently to sterility, and this result is hastened if the food contains unusual proportions of carbohydrates, especially sugar."

Wallace[3] states that barrenness may be caused by either over feeding, thus loading the reproductive organs with fat, or by keeping the animal in too low condition, especially if accompanied by exposure to wet and cold.

Eckles[4] found that heavy fed dairy heifers conceived just as readily as light fed ones. He says,

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1. Physiology of Reproduction, Chapt. 14.
2. Principles of Breeding, p 226.
3. Farm Live Stock in Great Britain, 4th Ed. p 22.
4. Missouri Bulletin No. 135.

"Results seem to indicate that even where the conditions are extreme there is little effect upon the reproductive function. The same might not hold good in case of older cows that had been allowed to become too fat."

Kisch[1] states that obesity is a common cause of sterility in women.

The writer has not thought it necessary to quote the opinions of all prominent agricultural writers on the frequency of sterility among highly fed farm animals. These writers are practically unanimous, however, in the opinion that a high condition is often conducive to barrenness.

That nutrition may cause sterility by other means than extremely high condition is indicated as a possibility by the general opinion of dairymen that too many cows fail to get with calf after making a high milk record on a forced test. The writer has been unable to obtain any statistics upon this condition, or any data as to the pathological conditions of the reproductive organs of a cow barren from this cause. It is said, however, that barrenness from this cause does not result from the failure of the cows to come "in heat" but from failure of the cows to conceive after being bred. A detailed post-mortem examination of the reproductive organs of some of these sterile cows would possibly explain the primary cause of the sterility.

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1. The Sexual Life of Woman (Paul's Translation) p 479.

Hart, McCullum and Steenbock, and Humphrey[1] found that although rations limited to the products of certain single plants affected very materially the growth, oestrum periods, and the offspring of heifers, that these rations appeared to have no effect upon conception when the heifers were bred, there being practically no difference between the lots in this respect.

Hunziker[2] has investigated the effect of cotton seed meal upon the breeding properties of cows, and states that his data is too meagre from which to draw final conclusions. He adds, "Judging from the work that is completed along this line it may be stated that very little effect if any is noticed in regard to this feed as a preventive of proper conception."

Aside from the male element it is evident that conception followed by normal birth depends upon three factors: ovulation, its prevention or the decrease or increase in the number of ova produced; fertilization, which is affected by such conditions as some malformations of the female reproductive organs which would prevent the spermatozoa from reaching the ova, or a pathological condition of the organs which would be fatal to the life of the spermatozoa before they reach the ova; and third the death of the foetus followed by atrophy or abortion.

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1. Wis. Research Bulletin No. 17.
2. Purdue Report 1915

Hammond[1] cites several investigators who have found atrophied foetuses in the uteri of females of several species of animals, or foetal membranes at birth. He suggests that this might often be a cause of sterility. In attempting to ascertain the cause of these atrophied foetuses, he dissected the uteri of several pregnant rabbits, sows, and a bitch. Finding that apparently the atrophies were no more apt to be in the horn of the uterus containing the larger number of foetuses than in the one containing the smaller number, and that there was no definite relation between the size of the foetus and the relative number in the horn, he concluded that the atrophies cannot be due to insufficient nutrition. He draws no final conclusions, but suggests the possibility of the atrophies being caused by lack of vitality of the foetus, due probably to heredity. It seems improbable that early death and atrophy of the foetus could be the cause of continued barrenness in cows when that barrenness is apparently the result of faulty nutrition.

Marshall and Peel[2] made a detailed examination of the reproductive organs of seven fat cows which had failed to conceive. It seems to be the opinion of these authors that the sterility of these heifers was largely due to the disturbance of or the absence of the period of oestrum;

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1. Journal Agr. Sc. Vol. 6, pp 263- 277.
2. Journal Agr. Sc. Vol. 3, pp 383 - 389.

although they do mention that some of the cows came in heat, at least irregularly. They found lipochrome in the interstitial tissues of the ovaries and attributed the irregularity of oestrum periods to disturbed ovarian metabolism, as indicated by the presence of lipochrome. They also found degenerate follicles in some of the ovaries, and state that this could be caused by failure to ovulate, and according to Heape, this if continued leads to sterility in the rabbit. They add, "Lastly it is always possible that in cases of extreme "fatness" sterility may be caused simply by mechanical factors, such as the blocking or anatomical derangement of the Fallopian tubes, and the consequent incapacity of the ova to gain access to the tubes, owing to an excessive deposition of fat in that region." They add that not more than one case of sterility in the above cases could be attributed to this cause, and it was far from certain in this instance.

Williams[1] says that ovarian cysts are especially common in highly fed stabled cows, but also adds that the primary causes of this disease are unknown.

It is evident that barrenness occurs too frequently among highly fed females. It is a question which merits further careful research. More post-mortem examinations similar to those by Marshall and Peel would possibly shed valuable light on the primary causes.

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1. Veterinary Obstetrics, page 170.

GESTATION.

The period of gestation as here considered is the time elapsing between date of service and parturition. As the time of ovulation is a factor in determining the time of fertilization of the ovum, it is also a factor influencing variation in the length of gestation. That is, variations in the time between service and fertilization may also cause a variation in the length of gestation. According to Williams[1], ovulation in the cow probably occurs late in the period of oestrum. His conclusions are based upon observations made during the spaying of a large number of cows, and he says, "We have regularly observed that the one which is in oestrum has ripe ovisacs which generally rupture the moment the ovary is grasped. If the cow has been in oestrum the previous day we have found the Graffian follicle freshly ruptured." Owing to the short period of oestrum, this may not be as important a factor in the cow as in the case of some other animals.

Marshall[2] cites the theories of several writers who have attempted to explain the stimuli which start parturition, but he says that as yet none of these theories have been proven, and while some of the reasons advanced may at least be factors in the cause of parturition, proof is lacking and the question is still unsolved.

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1. Veterinary Obstetrics, p 115.
2. Physiology of Reproduction, Chapt. XII.

No less an authority than Heape[1] has suggested the possibility of nutrition affecting the length of the gestation period, and he says, "A correspondent who is a sheep breeder informs me that his ewes when run on poor land experience an appreciably longer gestation period than those run on rich land, and I am strongly inclined to think investigation will show that the supply of food and the quality of food have very marked effects, not only upon the breeding seasons and the gestation periods, but upon the fertility generally, upon the mother, and upon the foetus."

Wing[2], studying the records of the Cornell dairy herd, says first, that there was practically no difference in the gestation periods when male or female were delivered; second, that the individuality of the cow may be a factor, as it was noticed that some cows had a tendency to either abnormally long or short gestation periods, but that still other cows showed considerable variability in the lengths of their different periods; and third, that the average length of period terminated by twin births was five days shorter than the average periods terminated by single births.

Hart, McCullum and Steenbock[3] found that the gestation periods of cows fed entirely on the corn plant varied only slightly from the calculated time, but that those cows fed entirely on the wheat plant delivered their calves from two to five weeks early. These latter births

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1. Quart Journal Micr. Science, Vol. 44, p 14.
2. Cornell Bulletin No. 162.
3. Wisc. Research Bulletin No. 17.

were evidently premature, as the calves were all undersized, and dead or very weak at birth.

Wellman[1] concludes that there is a seasonal variation with some animals at least. "With brood mares the average length of the gestation period in the case of 5437 births was 334.67 days. The periods were shortest in the births which occur in July, the average length for that month being 321.94 days. From July there was a constant increase from month to month until May, when it reached 346.11 days. With working mares the average length of the period in 171 cases was 325.63 days, with the seasonal variation as in the case of the brood mares. The average gestation period of 228 Hungarian cows was 284.61 days, and of 291 Simminthal cows 291.2 days. Apparently there was a seasonal variation in cows, but much less in amount than in the case of horses."

According to Sabatina[2], in horses, cattle, and sheep the length of gestation is shorter with twins than with single births, with the first born than with later pregnancies, with a female foetus than with a male, and in early maturing than with late maturing breeds.

Pinard[3] gives statistics on cows, showing that gestations terminated by twin births average shorter than the average period for cows, and eight days shorter than

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1. Cited from Experiment Station Record, Vol. 24, p 75.
2. Cited from Exper. Station Record, Vol. 20, p 1170.
3. Cited from Richert Dictionnaire de Physiol. Vol. 7, pp 122 - 188.

the average of periods terminated by single births for the same cows.

Robertson[1], studying the duration of pregnancy in Australian women, states that the average was a little longer in the case of the female child, and that eliminating abnormal periods and applying biometrical methods, this becomes even more apparent, and that there are 142 chances to one that this conclusion is correct.

Williams[2] states that the duration of pregnancy in women probably depends to some extent upon individuality, and also quotes Mme. Laurie, who cites that women who entered the hospital several weeks before labor went twenty days longer than those who entered at the onset of labor. Therefore he states that hard work and poor nourishment predisposes somewhat to premature birth.

Owing to the frequent inaccuracies in stating the length of the gestation period in women on account of the method of calculating the time, the writer has included here no other literature than that quoted above.

Carlisle and McConnel[3], from a study of the flock records of the University of Wisconsin, state that the length of the gestation period varies slightly with the breed, but that the sex of the lamb is not a factor as is often supposed.

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1. Amer. Jour. of Physiology, Vol. 37, pp 1 - 42.
2. Obstetrics, p 170.
3. Wisconsin Bulletin No. 95.

Humphrey and Kleinheinz[1], from the same source but at a later date, call attention to the fact that the latter records show that on the average the male lamb is carried slightly longer than the female, but they state that their evidence is too meagre to be conclusive, and that it may be a variation caused by too few numbers from which to calculate an average.

Minot[2] states that in guinea pigs the larger litters had on the average a shorter gestation period than the smaller ones.

Pinard[3] found that in rodents when the mother was suckling a normal number of young during gestation that the length of the period was prolonged, but that if the number suckled was less than normal the prolongation was not so marked, and that in the case of mice the prolongation of the period was in direct proportion to the number of young suckled.

Daniels[4] observed that in mice the gestation period of lactating females was longer than in those which were not suckling young, and also that the prolongation of the gestation period was in direct proportion to the number of the young suckled. He says that his data is too meagre from which to draw definite conclusions, but suggests the following explanation; that this must be due to one of the

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1. Wisconsin Report 1907.
2. Journal of Physiology, Vol. 12, pp 97 - 163.
3. Cited from Richert Dictionnaire de Physiol. V.7, pp 122-188.
4. Experimental Zoology, Vol. 9, p 865.

two following factors: delayed ovulation, or to retarded growth of the foetus caused by insufficient nourishment.

He believed it to be the latter for the reason that in one female, which had previously had two prolonged gestation periods accompanied by lactation, parturition was shortly followed by copulation; but by the fourth day thereafter all of the young mice in the litter had died and the gestation period was normal. As lactation started but ceased shortly it appears that the prolongation of the shorter periods was caused by its continuance and not by its early effect.

Miss King[1] found that the length of the gestation period in the albino rat is prolonged by lactation, providing the young carried or suckling exceeds the average number for the species. Smaller numbers did not seem to affect the length of the period. She attributes this delay to retarded growth of the foetus, caused by insufficient nourishment.

It is evident that the length of the gestation period varies more or less with breed, individuality, and possibly other factors, but the information upon the question of the food supply affecting the length of the period in the large domestic animals is too meagre and indirect to even warrant a prediction.

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1. Biological Bulletin, Vol. 24, pp 377 - 391.

BIRTH WEIGHT.

Eckles[1] found the amount of food required to nourish in utero the foetus of a cow is insignificant, and that a healthy cow receiving a maintenance ration during gestation should not suffer from insufficient nutrition. He[2] also found that there was practically no difference in the average birth weights of calves from light and heavy fed dairy heifers, and states, "Breed rather than feed is the controlling factor." From a study of the calves dropped in the dairy herd at the University of Missouri, the same author[3] concludes, first, that males are larger than females at birth; second, that breed is the largest factor influencing size, third, the maturity of the cow has some effect, the calves from mature cows averaging heavier than calves from immature dams, and fourth, that the size and vigor of the calf at birth is not influenced as much as might be expected by the previous feeding and condition of the dam; and also fifth, that when a cow is excessively fat the calf in many cases is somewhat undersized.

From a study of the calves dropped in the dairy herd at the Connecticut Station, Beach[4] concludes that the size of dams and the breed are factors affecting the birth weight of calves.

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1. Musser - Masters Thesis, M.U. 1914.
2. Missouri Bulletin No. 135.
3. Milk Production, p 174.
4. Connecticut Report, 1907, p 147.

Hart, McCullum and Steenbock, and Humphrey[1] in their investigations on the effect on growth and reproduction of rations from restricted sources, found that the birth weight was affected by the character of the ration. The calves from the cows fed on the corn plant were the largest and strongest, the calves from the oats fed group were next, the group fed a mixture of the corn, oats and wheat plants were third, and the calves from the wheat-fed group were the smallest. The difference in this last group was the most marked. However, many of the calves in this group were born dead and the others were weak at birth, and the period of gestation was very much shorter than with the other groups. Thus it might be argued that instead of affecting the birth weight, the ration affected the length of the gestation period, causing premature birth and consequently a smaller birth weight in the offspring.

Pearl[2] has cited several authors who conclude that the male averages a larger birth weight than the female.

Scott[3] , from the birth weights of a few calves incidentally suggests the possibility of the season of the year as a factor, but his data is very meagre and he draws no definite conclusions.

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1. Wisconsin Research Bulletin No. 17.
2. Maine Bulletin No. 204.
3. Florida Bulletin No. 110.

Mumford[1], experimenting with sheep, says that the ram did not appear to influence the birth weight of the lambs, but that the weight of the ewe and the sex and number of lambs at birth are factors.

Humphrey and Kleinheinz[2], from a study of the flock records of the University of Wisconsin, conclude that the number of lambs at birth, the sex, the size of the ewe are factors affecting the birth weight. With the single lambs the breed was a factor, but with twins and triplets the breed seemed to have no influence on the birth weight. The size of the ram was not a factor.

Carlisle and McConnel[3] at a previous date, also studying the flock records of the University of Wisconsin, state that the length of the gestation period seems to affect the weight of the lamb at birth.

Carlisle[4] concludes that in pigs the size and age of the dam influence the total weight of the litter.

Evvard[5] found that gilts fed corn supplemented with some protein feed produced larger pigs than gilts fed a ration of corn alone. He also reports that the ration of the ewe affects the size of lambs at birth, but not to as great a degree as in case of pigs.

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1. Missouri Bulletin No. 53.
2. Wisconsin Report 1907, pp 25 - 40.
3. Wisconsin Bulletin No. 95.
4. Wisconsin Bulletin No. 104.
5. Amer. Breeders' Magazine, Vol. 8, p 549.
   Proc. Iowa Acad. Science, Vol. XX., pp 325 - 330.

Evvard, Dox, and Guernsey[1] report that sows which received calcium in addition to corn farrowed larger pigs than sows fed a ration of corn alone; while the addition of a high protein supplement to the corn produced even a more marked increase in the birth weight of the pigs.

Williams[2] says that the birth weights of children are affected by the sex, race, size of parents, parity of the mother, her mode of life, her nutrition and physical condition during the months of pregnancy. He says that if pregnancies have not followed in two rapid succession the birth weight of the children increases up to the twenty-eighth or thirtieth year of the mother, and generally succeeding pregnancies follow the same rule. He states that especially the size of the father exerts an influence on the size of the child. He states that children of heavy weights are more common in the upper walks of life than in families of limited means. He attributes this to the comforts of the mother. He quotes the work of Pinard and Bachmont, who observed that the children from patients who had entered the hospital three months prior to confinement averaged 500 grams heavier than the children from mothers who entered the hospital during or just prior to labor. They attribute this to better nourishment of the patients and the absence of hard work, which is accompanied with a tendency to premature labor.

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1. Amer. Journal of Physiology, Vol. 34, pp 312 - 325.
   Proc. Iowa Acad. Science, Vol. XXI. pp 269 - 278.
2. Obstetrics (1903) pp 132-135.

Ballantyne[1] says that it has been maintained that the nutrition, employment, health, age, size, parity, duration of menstrual flow, date of the commencement of the reproductive life of the mother, the sex of the child, the length of the cord, the amount of liquor amnii have certain relations to the size of the child at birth. According to this author the above factors do not really explain the marked variations which occur in the weights of children at birth. He adds further that although attempts have been made to regulate the growth of the foetus by controlling the diet of the mother, they have not met with conspicuous success. "The factors of foetal nutrition are so numerous and their relations so intricate, that it is impossible to arrive at the coefficient of nutrition, so to speak." However, he further adds that the health, food, and employment of the mother during pregnancy may be factors to a certain extent; for, according to Bachimont, there is reason to believe that they do affect the structural and physiological integrity of the placenta, the activity of the foetal organs of assimilation, and the state of the growth dominating glands both in the mother and the foetus. It appears to be his opinion that the birth weight is largely determined at conception by heredity.

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1. Antenatal Pathology and Hygiene (1902) p 167.

Duncan[1] presents statistical data to show that the birth weight of the child increases with the age and the parity of the mother up to a certain climax, and thereafter decreases. He says that longer gestation periods in older women may account for this difference in size.

Prowchonick[2] restricted the diet of forty-eight pregnant women and records an average birth weight of 2960 grams for twenty-four male children, and 2735 grams for twenty-four female children. It having been found that the average birth weight of male children was 3300 grams and 3200 grams for females, he concludes that this difference is due to diet.

Leicester[3], studying the relation between the length of the gestation period and the weight of the child, reports that the weight seems to increase with the length of the period with European women in India, and East Indian mothers, but his figures showed practically no difference in the offspring of native Indian women.

Lane[4], from measurements of a large number of women, concludes that there is a direct relation between the conjugate diameter of the pelvis and the weight of the foetus.

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1. Fecundity, Fertility, and Sterility. 2d Ed. pp 47-66.
2. Cited from Patton - Lancet, July 4th, 1903.
   Newman - Infant Mortality (1907) p 84.
   Williams - Obstetrics, p 176.
3. Journal of Gynaecology and Obstetrics of the British Empire. Vol. XI. pp 465 - 469.
4. Lancet, 1903. 885 - 889.

Robertson[1], recording the birth weights of several Australian children, says that the males average heavier than the females; that there is a tendency for the birth weight to increase with the length of the period of pregnancy, and that this becomes even more apparent when the records of those periods which have evidently been miscalculated are eliminated from the table. He also says that the birth weights of these Australian children are greater than is given by writers for the average weights of English children of the same class of parents (laboring). He attributes this to better nourishment of the mother and easier employment during pregnancy.

Patton[2] reports an experiment with guinea pigs where by restricting the diet he reduced the average weight of the offspring at birth to a considerable extent below that of normally fed pigs. He states that there were no indications that this was due to premature birth.

Minot[3] found that with guinea pigs the birth weight decreases with the increase of the number in the litter. He states that in his experiments this could not be due to insufficient nourishment of the foetuses, as the mothers were well fed and did not suffer from a lack of nourishment as was indicated by the fact that gestation did not interfere with their growth. These larger litters were

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1. Amer. Journal of Physiology. Vol. 37, pp 1 - 12.
2. Lancet, July 4th, 1903.
3. Journal of Physiology. Vol. 12, pp 97 - 163.

accompanied by a shorter gestation period, and he attempts to explain the smaller individual birth weights on that basis; namely, their birth weights were smaller because the offspring had a shorter time in utero to grow. He noted that in his work the litters which were borne during the summer were considerably heavier than those borne during the winter, but he did not attribute this to a seasonal difference but rather to nutrition, as he stated that the mothers during pregnancy were better fed in the summer months than during the winter season. The wide variations in the individual weights of the same litter might be due to difference in heridity or to difference of nourishment in the uterus, one foetus receiving a larger blood supply than the others.

Cole and Isben[1], studying the factors which control the weight of guinea pigs at birth, state that trials seem to indicate that the length of the gestation period is a factor, but that the kind and amount of food supplied to the mother during gestation is more important, and that the size and the age of the mother are also factors; but there is no relation between the weight of a guinea pig at birth and its position in the order in which the litter is borne.

Miss King[2], investigating the factors which affect the birth weight of the albino rat, states that the

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1. Wisconsin Bulletin No. 250.
2. The Anatomical Record. Vol. 9, p 213.

difference between members of the same litter may be due in part to the fact that ovulation has extended over a space of considerable time, some of the ova thereby becoming fertilized at a later date than others, thus the real differences are due to a difference in the age of the embryos. She states that the birth weight varies with different strains or families of rats, that males average heavier than females, that the age, size, physical condition of the mother, and the number of litters which she has borne previously, and the number of young in the litter are factors. She also states that the evidence for definite conclusions is insufficient, but that it appears that increasing the gestation period for even one day materially increases the weight of the young at birth.

Thus it appears that the birth weight is largely determined by heredity, but that in some animals it is influenced to a more or less degree by external factors. In cattle it appears that the breed, age, and size of the dam, and the sex of the calf influence the birth weight, but that as yet there is no evidence indicating that the birth weight of normally developed calves can be influenced by external factors, such as the food supply of the dam; although this is plainly the case in some other species of animals.

COMPOSITION OF THE CALF.

The writer has been able to find only a small amount of literature bearing upon the question of the nutrition of the dam affecting the composition of the foetus.

Evvard[1] reports that there was no difference in the analysis of pigs farrowed by gilts fed a ration of corn during pregnancy and the pigs from gilts fed a ration of corn with different protein supplements.

Hart, Steenbock, and Fuller[2] report that there was no difference in the lime content of the pigs from sows receiving different amounts of lime in their ration during pregnancy.

Schkarin[3] reports that the diet of the bitch did not materially affect the phosphorous content of her pups at birth.

Hogan[4] compares the analysis of a new born calf with that of a foetus 185 days old, and shows that the latter contains a larger percentage of moisture, but that calculations made on a dry basis show that there is not much difference in the protein content; while on the same basis the percent of ash is higher in the new born calf.

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1. American Breeders' Magazine. Vol. 8, p 549.
2. Wisconsin Research Bulletin No. 30.
3. Cited from Ohio Tech. Bulletin No. 5, p 471.
4. Masters Thesis, M.U. 1912.

The same author has reviewed the work of former chemists, showing that in the human foetus the sex does not influence the chemical composition, that the percent of moisture decreases and the percent of fat increases with the age of the foetus, and that calculated on a dry basis the percent of protein is higher during the earlier stages; while the ash remains about the same.

According to Connell[1] there is a difference in the ash constituents of Jersey and Hereford calves and of full term and premature calves.

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1. Masters Thesis. M.U. 1914.

EXPERIMENT.

The object of this experiment was to determine the effects of different planes of nutrition on cost of maintenance and reproduction in beef cows. Since the cows were immature at the beginning of the experiment, a series of body measurements was taken on each cow at regular intervals to note the rate of growth. A record of the salt consumed by each cow was kept, in order to compare the different lots.

Data was secured on the following points:-

1. Frequency and regularity of the period of oestrum.
2. Number of services required for conception.
3. Length of gestation period.
4. Weight of calves at birth.
5. Growth of the calves after birth.
6. Chemical composition of the calves at birth.
7. Growth of the cows.
8. Salt consumed.
9. Feed consumed.

DATE OF THE EXPERIMENT.

The feed and salt data and weights included herein cover a period of three years and 135 days, beginning August 21st, 1912, and ending January 2d, 1916. The experiment was continued after this date and no change was made in the plane of nutrition of any lot; each lot receiving exactly the same treatment to which it had been accustomed prior to January 2d, 1916. Completion of this paper within the required time necessitated the calculation of this data to that date only. The first body measurements were taken August 15th, 1912, six days prior to the beginning of the feed and weight records. The last body measurements considered in this paper were taken January 2d, 1916. To make a part of the data herein more complete, calves No. 566B, dropped February 6th, 1916, and No. 568C, dropped March 22d, 1916, are included in the data on weight of calves at birth and the length of the gestation period.

COWS USED.

Nine head of registered Hereford cows were used in the experiment. They were purchased from Mr. J. E. McPherson, of Columbia, and were shipped to this place from Lockwood, Mo., where they had been selected from

a herd of about fifty head. All their lives they had received what might be termed medium farm treatment, and at no time had they been pampered. They were supposed to be unbred when purchased, but cow No. 560 dropped a calf on November 3d, 1912. This calf is designated by the number 560A, and is not included in any of the calculations herein. They were divided into three lots as indicated in Table I., which contains a summarized description, at the beginning of the experiment, of each heifer, and an average of each lot, giving the number by which each cow is known in this experiment, her name and registration number, name of her sire, birth date, age in days, weight, and height at withers. Note from the table that the bull Lord March On sired one, while Beau Brummel Anxiety sired two heifers in each lot, and also that the widest difference in the average ages of any two lots was only twenty-one days; the greatest difference in average weight thirty-six pounds; and in average height at withers only 1.8 centimeters. Following page 44 is a series of photographs of the heifers, which show them to be very similar in type and condition at the beginning of the experiment. It would have been very difficult indeed to have secured nine heifers which were nearer equal in age, breeding, size, condition, and previous treatment.

TABLE I.

Summarized Description of the Cows used at the Beginning of the Experiment.

Exp. No.	Name and Registration Number.	Sired By	Birth Date 1911	Age at Begin. of Exp. Days.	Weight lbs.	Height at Withers cm.
560	Express 7th 386563	LMO	Feb. 9th	558	672	109.6
561	Miss Cue 2d 386569	BBA	Mar. 5th	534	626	112.4
562	Empress 8th 386564	LMO	Feb. 10th	557	625	117
Ave. Lot I.				550	641	113
563	Elma 4th 386560	LMO	Mar. 24th	515	650	112
564	Miss Elizabeth 386566	LMO	Mar. 7th	532	713	112.8
565	Miss Kemper 3d 386567	BBA	Feb. 28th	539	625	111.5
Ave. Lot II.				529	663	112.1
566	Emma 3rd 386561	BBA	Mar. 10th	529	691	111.5
567	Armour Pet 2nd 386555	LMO	Mar. 1st	538	570	108.5
568	Empress 7th 386562	LMO	Feb. 28th	539	635	113.4
Ave. Lot III.				535	627	111.2

Note: LMO, Lord March On, 178489.

BBA, Beau Brummel Anxiety, 229745.

PLANE OF NUTRITION.

When the trial started all three lots were on the same plane of nutrition. Lot I. was changed to a high plane, Lot II. was left on a medium plane, while Lot III. was reduced to a low plane. By giving the cows in Lot I. a full feed it was planned to fatten and maintain them in that condition during the trial. The cows in Lot II. were to be kept in a good thrifty condition without any surplus flesh. The cows in Lot III. were to be reduced and maintained in a thin and emaciated condition throughout the trial.

It was hoped that the cows in Lot I. would compare favorably to some pure bred herds which are maintained under highly artificial conditions. The cows in Lot II. were to compare to grade cows often found on corn belt farms. The conditions in Lot III. were to compare to conditions sometimes found in sections of the southwest range district. The only difference in treatment accorded the different lots was in the amount of feed given.

BULLS USED.

The bulls used on the cows were pure bred Herefords, Beau Ultra and Grand Stanway. They were being used in the college herd during this time, and were maintained in what might be termed medium high condition. Photographs following this page indicate their type and condition.

EQUIPMENT AND METHOD OF FEEDING.

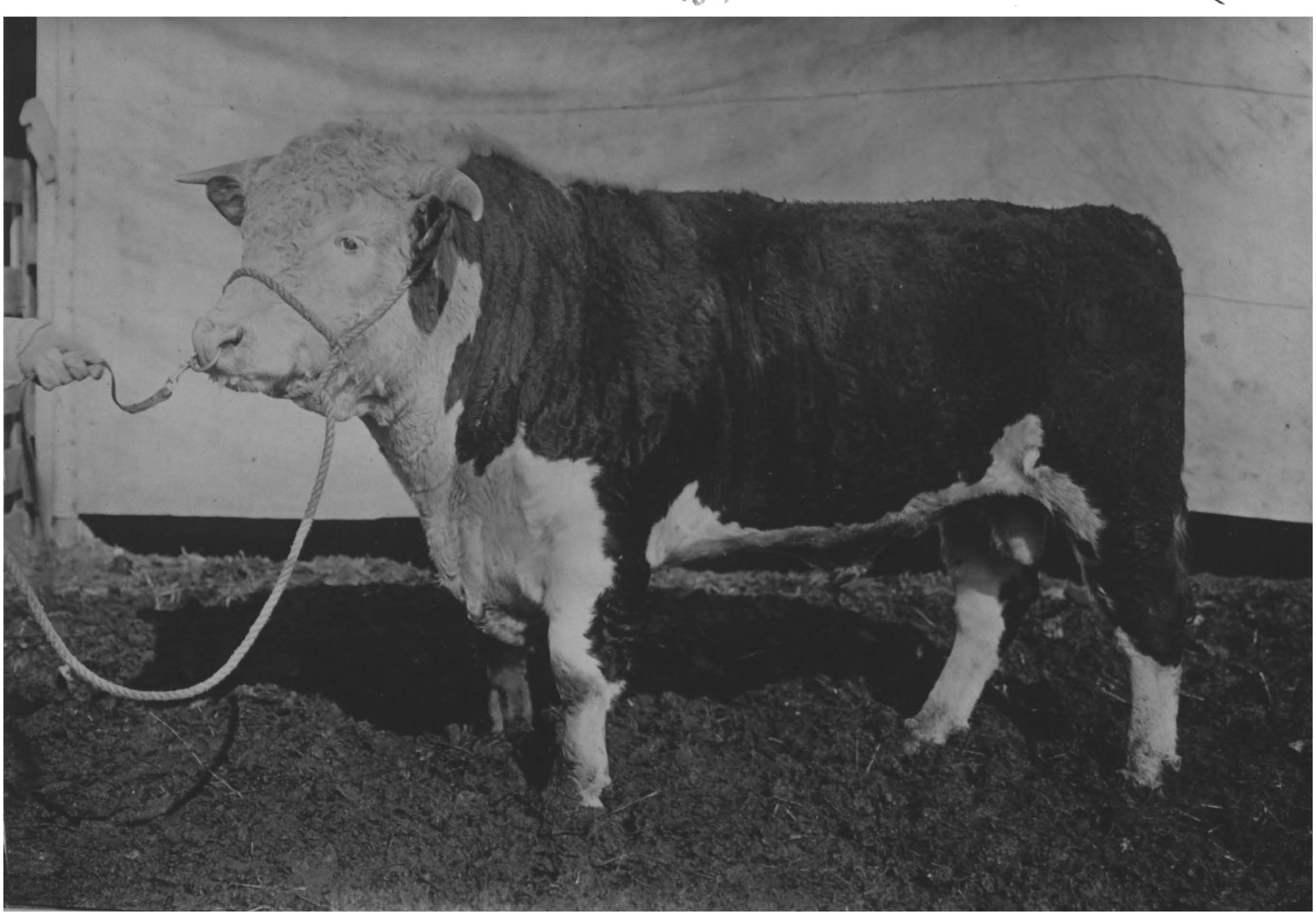
During the trial each lot was confined in a pen about 16 by 114 feet, at the "Adams" shed. These pens sloped toward the south, and the north ends of the pens were covered by a shed open on the south. In the north end of each pen were three stanchions and a closed door in front of each stanchion prevented one cow from eating out of another cow's feed box between feeding times.

The cows had access at all times to water supplied in tanks.

Salt was supplied in a small box at the side of each feed trough, and no attempt was made to regulate the amount consumed. The amount consumed was computed by the following method: At the beginning of each ten-day period salt was weighed into the box, and at the close of the period the amount remaining in the box was weighed out, the difference between the two representing the amount of

Plate 1.

Grand Stanway.



Beau Ultra.

salt consumed. The boxes were cleaned out and fresh salt was supplied every ten days. Owing to the difference in moisture content the above method is more or less inaccurate. However, any percentage of error is in all probability about the same in each lot; hence while the figures may not represent exactly the amount of salt consumed by each lot, they probably represent quite accurately the ratio of salt consumed between the different lots.

The cows were fed twice daily. Each heifer was placed in her stanchion, fed the hay and grain together, as soon as she finished eating she was turned out of the stanchion and the door in front of it closed. In this manner it was possible to keep a careful record of the feed consumed and refused by each cow.

CHARACTER OF THE RATION.

All lots received the same kind of hay and grain ration, the difference being in the quantity and not in the quality.

The grain ration consisted of a mixture of corn chop six pounds, wheat bran three pounds, and linseed oil meal one pound.

The hay ration consisted of alfalfa three pounds and oats straw two pounds. The hay and straw were run

through a feed cutter, in order to mix them more thoroughly; thereby insuring the consumption of both.

No attention was paid to the proportion of grain to hay fed. Any definite proportion of grain to hay would not have suited the needs of all the lots. If the proportion had been adjusted to suit the needs of the high plane lot, the ration of the low plane lot would have lacked sufficient bulk to insure normal nutrition. Had the proportion been adjusted to suit the needs of the low plane lot, the proportion of hay to grain would have been so great that it would have been impossible for the cows in the high plane lot to consume sufficient nutrients to become as fat as desired. The hay and grain mixtures were calculated to have approximately the same nutritive ratios. Thus, any change in the proportion of grain to hay would not materially affect the nutritive ratio of the ration. It was the intention to eliminate as nearly as possible the nutritive ratio as a factor affecting the results.

Table II. contains the nutritive ratios of the hay and grain mixtures during the different periods of the trial. The periods are determined by a change of the sample of one or more feeds on the date when the new period begins.

Note from Table II. that the nutritive ratios varied slightly, but the differences were not great. The proportions of the mixtures had been estimated previous to starting the experiment, and the analysis of the feed fed differed more or less from those used in making the calculations.

BREEDING:

It was planned to breed the cows at every heat period, and this was carried out as far as possible. A few times a bull was not available, which made it necessary to wait until some following period. A close watch was kept for any signs of the cows being in heat and reasonable precautions taken not to miss observing any heat period.

WEIGHTS.

Each cow was weighed every morning after finishing her morning feed. In calculating the average weight for a thirty-day period, an average was taken of the thirty weights taken during the period. Since no weights were taken prior to August 21st, 1912, an average of weights taken on August 21st, 22d, and 23d was taken as the initial weight for August 21st, 1912. An average of

TABLE II.

Nutritive Ratios of the Hay and Grain Rations Fed. #

End of Period	Grain	Hay
	1 :	1 :
1912		
Nov. 28th	6.26	7.34
1913		
May 27th	6.14	7.34
July 26th	5.52	7.34
Nov. 3rd	5.52	6.53
Nov. 24th	5.52	6.49
1914		
Feb. 11th	5.52	6.55
April 22d	4.87	6.55
July 21st	5.11	6.55
July 31st	5.35	6.45
Aug. 31st	5.43	6.45
Sept. 19th	5.49	6.45
Oct. 9th	5.44	6.45
Nov. 3rd	4.73	6.45
Dec. 12th	4.73	5.78
1915		
Jan. 17th	4.73	4.45
Feb. 16th	4.89	4.45
June 16th	4.98	4.45
Sept. 5th	4.92	4.73
Oct. 14th	4.92	6.59
Dec. 3d	5.39	5.51
1916		
Jan. 2d	5.49	5.51

Note # Computations made from analysis of feeds used and coefficient of digestibility taken from Henry and Morrison's "Feeds and Feeding" and given in Table XIX.

the weights taken December 31st, 1915, January 1st, 2d, 3d, and 4th, 1916, was taken as the final weight for January 2d, 1916.

MEASUREMENTS.

A series of thirty-two body measurements was taken on each cow at periods during the experiment. It was planned to repeat the measurements every forty-five days, but it was not always possible to take the measurements on exactly the forty-fifth day. A variation of a few days does not affect any of the conclusions considered in this paper. The cows were all measured on the same day, except in a few cases when it was impossible to conclude the measurements on the day started, in which cases they were finished the next day.

The list of measurements taken follows:

1. Height at withers.
2. Height at point midway between top of hips.
3. Height at top of hip points.
4. Height of chest floor just behind elbow joint.

4a. Height of hind flank.

5. Depth of chest just behind elbow joint.
6. Width of chest just behind elbow joint.
7. Width of paunch at end of last rib.
8. Depth of paunch at end of last rib.
9. Depth of twist.

10. Length of fore leg from elbow to the ground.

11. Smallest circumference of shin bone of fore leg.

12. Smallest circumference of shin bone of hind leg.

13. Length from point of hock to ground.

41. From withers to point of ischium.

14a. Length from base of horns to withers.

15. From highest point of withers to a line between hip tops.

16. From line between hip tops to the tail.

16a. Circumference of right thigh.

17. From point of shoulder to point of hips (front).

17a. From point of shoulder to end of ischium (average of both sides).

18. Length from point of shoulder to ground.

19. Girth of throat latch just back of jaw.

20. Length from pole to point of muzzle.

21. Length of face from line between eyes to point of muzzle.

22. Circumference of muzzle at opening of mouth.

23. Heart girth just behind elbow point.

24. Girth of paunch at end of last rib.

25. Girth of hind flank.

26. From top point of hips directly forward to last rib.

27. From top point of hips to ischium.

28. Width of pin bones inside.

29. Width of forehead.

30. Width of jaws (measure from outside).

31. Width of hips (measure from outside).

32. Width of loin.

Only "height at withers" is considered here, but the other measurements are available.

PHOTOGRAPHS.

Rear, front, and side view photographs of the cows were taken about every ninety days.
It is impossible to include all of the photographs here, so only the side views taken on August 20th, 1912; December 19th, 1912; December 23d, 1913; December 25th, 1914; and December 29th, 1915, are included and follow page 44.

CALVES.

In the discussion of the calves, each calf is designated by the number of its dam, followed by the letter A, B, or C, which indicates that it is the first, second, or third calf of the cow of that number. Thus, a calf numbered 560C is the third calf of cow No. 560, or calf No. 563A is the first calf of cow No. 563.

Calves Nos. 560A, 561A, 563A, 564A, 566A, 567A, and 568A were grown to different ages to secure data on

the effect of the plane of nutrition of the dam during pregnancy on the growth of the offspring after birth, but owing to the small number of calves it is impossible to draw any conclusions from the data on hand. The remaining calves were delivered to the Agricultural Chemistry Department immediately after birth, for analysis, to secure data on the effect of the plane of nutrition during pregnancy on the chemical composition of the calf at birth. As soon as the calves were dropped they were weighed, which weights are found in Table XXIX.

LACTATION RECORDS.

Cow No. 560 was not milked following her first two calves. In all other instances the cows were kept in milk for approximately seven months after calving. When the calves were taken for analysis the cows were milked by hand, and when the calves were grown they were allowed to suck, and the total amount of milk produced by the cow was estimated by milking out one quarter of the udder for four milkings at regular intervals during lactation. The amount of milk produced does not affect any of the conclusions considered in this paper, but is a part of the data, and with the length of the lactation periods follows in Table III.

TABLE III.

Lactation Records.

Cow No.	Period Began	Period Ended	Length Period Days	Total Milk lbs.	Av. Milk per day lbs.
560	Oct. 28, 1914	May 25, 1915	210	2899.4	13.8
562	Mar. 24, 1914	Oct. 19, 1914	209	2922.0	14.0
	May 19, 1915	Dec. 19, 1915	215	2974.6	13.8
563	Nov. 9, 1914	June 8, 1915	212	1553.5	7.3
564	Oct. 5, 1913	May 2, 1914	210	2784.0	13.2
	Dec. 12, 1914	July 9, 1915	210	2634.0	12.5
565	May 28, 1914	Jan. 27, 1915	244	1159.4	4.75
	June 27, 1915	Jan. 2, 1916	# 190	1216.8	6.4
566	Oct. 31, 1913	May 28, 1914	210	2021.0	9.6
567	Nov. 12, 1913	June 9, 1914	210	1999.5	9.5
	July 15, 1915	Jan. 2, 1916	# 172	734.0	4.3
568	Nov. 22, 1913	June 19, 1914	209	1268.9	6.07
	Dec. 8, 1914	July 4, 1915	209	925.0	4.4

Note # These periods not completed on January 2d, 1916.

FEED AND NUTRIENTS CONSUMED.

Table IV. contains the average daily amount, per head and per 1000 lbs. live weight, of feed and nutrients offered each cow, and the averages of each lot during the experiment. Tables V. to XIII. inclusive contain the amount per head and per 1000 lbs. live weight of grain, hay, protein and total nutrients consumed by each cow during each thirty-day period of the experiment. Tables XIV. to XVI. inclusive contain the averages of the same for each lot. Each table from IV. to XVI. inclusive, is divided into two sections (a) and (b). The section of the table designated as (a) contains the total amount of nutrients and feed, and section (b) contains the amount per 1000 lbs. live weight.

Note from Table IV. that the proportion of grain to hay was greater in the high plane lot. Approximately, Lot I. consumed 2 lbs. of grain to 1 lb. of hay; Lot II. 1 lb. of grain to 2 lbs. of hay; and Lot III. 1 lb. of grain to 5 lbs. of hay.

The difference in the average daily amount of ash consumed by the different lots was not great, but the lower plane lots consumed a slightly larger amount of ash per head than the high plane lot, and consequently a considerably larger amount per 1000 lbs. live weight. The low plane lots received more ash because they consumed a larger amount of roughage than the high plane lot. There is no evidence

that any of the cows suffered from insufficient amount of mineral matter in the ration.

The average nutritive ratios of the rations fed the different lots were, Lot I. 1 : 5.7, Lot II. 1 : 5.8, and Lot III. 1 : 5.8.

Lot I. averaged 11.96 lbs. of total nutrients per day, Lot II. averaged 8.72 lbs., and Lot III. 7.06 lbs. per day. Lot I. also consumed the largest and Lot III. the smallest amount of total nutrients per 1000 lbs. live weight, but the difference was not as great as in the amount consumed per head.

Table XVII. contains the amount of orts from each cow, and the average for each lot during the experiment. In most instances the orts consisted of the coarser parts of the roughage ration. All of the orts have not been analyzed at this time (April, 1916); but the average of the analyses available is given in Table XVIII.

All chemical analyses were made by the Department of Agricultural Chemistry.

No digestion trial was run in connection with the experiment. The digestion coefficients used in calculating the nutrients in the rations were taken from Feeds and Feeding[1] and are given in Table XIX.

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1. Henry & Morrison, 15th Ed.

TABLE IV.a.

Average Daily Feed and Nutrients Consumed per Head during the Experiment, 3 years and 135 days.

(Amounts in Pounds)

Cow No.	Grain	Hay	Prot.	Total Nutrients	Ash
560	10.88	6.13	1.706	11.22	.9
562	12.07	6.17	1.85	12.07	.94
Avg. Lot I.	11.48	6.16	1.78	11.96	.92
563	4.2	9.8	1.17	7.97	1.0
564	5.29	11.45	1.34	9.49	1.18
565	5.28	9.73	1.29	8.69	1.01
Avg. Lot II.	4.923	10.33	1.27	8.72	1.06
566	1.84	11.93	1.03	7.15	1.12
567	2.89	10.08	1.04	7.04	.9
568	2.05	11.49	1.03	7.00	1.09
Avg. Lot III	2.26	11.17	1.03	7.06	1.07

TABLE IV.b.

Average Daily Feed and Nutrients Consumed per 1000 lbs. Live Weight During the Experiment, 3 years and 135 days.

(Amounts in Pounds)

Cow No.	Grain	Hay	Prot.	Total Nutrients	Ash
560	10.34	5.86	1.621	10.66	.86
562	10.62	5.43	1.63	10.6	.83
Avg. Lot I.	10.48	5.65	1.63	10.63	.85
563	4.51	10.51	1.25	8.57	1.07
564	5.79	12.51	1.46	10.37	1.29
565	6.11	11.26	1.5	10.06	1.16
Avg. Lot II.	5.47	11.43	1.4	9.67	1.17
566	2.29	14.79	1.28	8.87	1.39
567	4.18	14.60	1.5	10.2	1.43
568	2.74	15.34	1.37	9.34	1.45
Avg. Lot III	3.07	14.91	1.38	9.47	1.42

TABLE V.a

Cow No. 560.

Total Grain, Hay, and Nutrients fed during each thirty-day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sept. 19th	350	214	48.8	367.0
Oct. 19th	414	184.5	53.8	401.4
Nov. 18th	378	163	48.8	363.9
Dec. 18th	368	177	48.8	362.2
1913				
Jan. 17th	384	180	50.8	375.2
Feb. 16th	450	178	57.6	424.1
Mar. 18th	480	176	60.7	445.8
Apr. 17th	377	161.5	49.0	361.2
May 17th	470.5	186.5	60.3	443.6
June 16th	490	201	66.7	466.5
July 16th	400	180	56.9	388.9
Aug. 15th	338.5	193	51.5	350.6
Sept. 14th	287.2	161	44.0	296.9
Oct. 14th	181	128	29.4	200.2
Nov. 13th	203.5	150.5	33.5	228.2
Dec. 13th	198	182	34.9	239.2
1914				
Jan. 12th	240	180	39.6	270
Feb. 11th	240	204	41.2	281.8
Mar. 13th	240	180	40.5	257.7
Apr. 12th	236	177	39.9	253.4
May 12th	240	180	39.7	257
June 11th	240	180	39.2	256.7
Jul. 11th	240	180	39.2	256.7
Aug. 10th	244	180	40.2	266.7
Sept. 9th	238	180	39.5	267.6
Oct. 9th	240	180	39.7	268.5
Nov. 8th	270	180	47.3	290.9
Dec. 8th	360.5	180	59.6	356.6
1915				
Jan. 7th	390	180	66.1	377.2
Feb. 6th	390	180	66.4	381.6
Mar. 8th	390	180	66.0	385.0
Apr. 7th	390	221	69.5	405.1
May 7th	390	240	71.1	414.17
June 6th	280.1	236	56.6	327.7
July 6th	276	240	56.5	278.4
Aug. 5th	350	200	62.6	367.4
Sept. 4th	360	180	62.2	365.3
Oct. 4th	355	177.5	58.3	364.3
Nov. 3rd	336.5	168.25	54.3	345.3
Dec. 3rd	343.5	171.75	54.9	352.5
1916				
Jan. 2nd	340.5	170.25	53.0	344.3

TABLE V. b.

Cow No. 560.

Grain, Hay, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sept.19th	494.3	302.2	68.9	518.3
Oct. 19th	518.7	231.2	67.4	503.0
Nov. 18th	462	199.2	59.6	444.8
Dec. 18th	480.1	231.3	63.8	473.4
1913				
Jan. 17th	480.6	225.2	63.5	469.5
Feb. 16th	528.7	209.1	87.3	498.3
Mar. 18th	523.1	192.1	66.3	486.6
Apr. 17th	402.6	187.9	62.3	385.8
May 17th	463.5	183.7	59.4	477.0
June 16th	449.1	184.2	61.1	427.5
July 16th	350.5	157.7	49.8	340.8
Aug. 15th	288.3	164.3	43.8	298.6
Sep. 14th	237.7	133.2	36.4	245.7
Oct. 14th	170.2	120.4	27.7	188.3
Nov. 13th	210.4	155.6	34.6	235.9
Dec. 13th	206.0	189.4	36.3	248.9
1914				
Jan. 12th	242.6	182	40.0	273.0
Feb. 11th	235.1	199.8	40.4	276.0
Mar. 13th	233.2	174.9	39.3	250.4
Apr. 12th	224.7	168.5	38.0	241.3
May 12th	225.5	169.1	37.3	241.5
June 11th	217.1	162.8	35.4	232.3
July 11th	211.6	158.7	34.5	226.3
Aug. 10th	210.3	155.1	34.6	229.9
Sep. 9th	201.3	152.2	33.4	226.3
Oct. 9th	200.0	150.0	33.0	223.6
Nov. 8th	235.1	156.7	41.2	253.4
Dec. 8th	341.0	170.2	56.4	337.3
1915				
Jan. 7th	373.9	172.5	63.3	361.6
Feb. 6th	371.7	171.5	63.2	364.1
Mar. 8th	366.8	169.3	62.0	362.1
Apr. 7th	360.4	204.2	64.2	374.3
May 7th	358.4	220.6	65.3	380.7
June 6th	255.1	214.9	51.5	298.4
July 6th	251.8	218.9	51.5	253.3
Aug. 5th	313.6	179.2	56.0	328.8
Sep. 4th	314.6	157.3	54.3	319.0
Oct. 4th	299.3	149.6	49.1	306.8
Nov. 3rd	275.0	137.5	44.4	282.4
Dec. 3rd	270.8	135.4	43.2	277.7
1916				
Jan. 2nd	258.9	129.4	40.3	261.8

TABLE VI. a.

Cow No. 561.

Total Grain, Hay, and Nutrients Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sept.19th	342	234	49.1	370.4
Oct. 19th	427	226	57.5	431.0
Nov. 18th	464	228	61.5	460.0
Dec. 18th	476	238	63.6	472.8
1913				
Jan. 17th	498	236	66.0	487.9
Feb. 16th	536	238	70.1	517.5
Mar. 18th	522	230	68.2	503.1
Apr. 17th	520	236	68.3	504.5
May 17th	539	244.5	70.8	522.9
June 16th	491	234	68.7	487.9
July 16th	400	182	57.0	389.9
Aug. 15th	320	236	52.1	357.6
Sep. 14th	287.2	161	44.0	296.9
Oct. 14th	# 170	# 85	# 25.4	# 170.7

Note # Period only 17 days long; cow died.

TABLE VI. b.

Cow No. 561.

Grain, Hay, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	517.3	354.0	74.2	560.3
Oct. 19th	573.9	303.7	77.2	579.3
Nov. 18th	565.8	278.0	75.0	560.9
Dec. 18th	538.1	269.5	72.0	535.4
1913				
Jan. 17th	524.7	248.6	94.9	514.1
Feb. 16th	531.2	235.8	69.4	512.8
Mar. 18th	485.5	213.9	63.4	468.0
Apr. 17th	460.1	208.8	60.4	446.4
May 17th	443.9	201.4	58.3	430.7
June 16th	381.2	181.6	53.3	374.9
July 16th	300.9	136.9	42.8	293.3
Aug. 15th	235.6	173.7	38.3	223.8
Sep. 14th	207.5	116.3	31.7	214.5
Oct. 1st	# 119.7	# 56.3	# 17.8	# 120.2

Note # Period only 17 days long; cow died.

TABLE VII. a.

Cow No. 562.

Total Grain, Hay, and Nutrients Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	329	132	41.9	312.1
Oct. 19th	396	121	48.3	357.6
Nov. 18th	399	168.5	51.3	382.5
Dec. 18th	363	168	47.8	354.1
1913				
Jan. 17th	367	174	48.6	359.6
Feb. 16th	440	153	55.1	404.7
Mar. 18th	459	154	57.2	419.5
Apr. 17th	462	182	59.1	435.0
May 17th	433.5	183.5	56.2	414.3
June 16th	435.5	174	59.0	412.0
July 16th	361	169.5	51.7	354.3
Aug. 15th	356	178	52.6	356.5
Sep. 14th	320.4	161	47.8	322.1
Oct. 14th	300	150	44.7	301.2
Nov. 13th	296	150	44.3	298.1
Dec. 13th	244	178	40.0	272.0
1914				
Jan. 12th	240	180	39.6	270.0
Feb. 11th	240	218	42.1	288.6
Mar. 13th	240	180	40.5	257.7
Apr. 12th	265	174	43.2	272.4
May 12th	300	180	46.7	299.2
June 11th	353	180	52.2	336.1
July 11th	360	180	53.0	341.0
Aug. 10th	369	180	54.7	358.2
Sep. 9th	420	180	60.6	403.7
Oct. 9th	420	180	60.4	402.6
Nov. 8th	331	180	55.2	336.4
Dec. 8th	360	180	59.5	356.3
1915				
Jan. 7th	339.5	180	59.5	338.5
Feb. 6th	330	180	60.0	336.08
Mar. 8th	330	180	58.3	338.98
Apr. 7th	310	180	55.6	324.09
May 7th	299.5	174	53.7	313.2
June 6th	300	201	56.1	326.4
July 6th	300	289	63.7	371.1
Aug. 5th	391.5	240.25	71.5	419.0
Sep. 4th	450	225	77.8	456.7
Oct. 4th	479.5	239.75	78.8	487.7
Nov. 3rd	480	240	77.4	492.6
Dec. 3rd	468	234	74.8	480.3
1916				
Jan. 2nd	475	237.5	74.0	480.4

TABLE VII. b.

Cow No. 562.

Grain, Hay, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	501.5	201.2	63.8	476.0
Oct. 19th	550.0	168.0	67.0	496.6
Nov. 18th	511.7	216.3	65.8	495.0
Dec. 18th	441.0	204.1	58.0	430.5
1913				
Jan. 17th	426.7	202.3	56.5	418.1
Feb. 16th	487.2	169.4	61.0	448.1
Mar. 18th	483.3	162.1	60.2	441.7
Apr. 17th	467.4	184.2	59.8	440.2
May 17th	421.2	178.3	54.6	402.6
June 16th	404.3	161.5	54.7	382.5
July 16th	325.8	152.9	46.6	319.7
Aug. 15th	316.7	158.3	46.7	317.1
Sep. 14th	277.8	139.6	41.4	279.3
Oct. 14th	254.8	127.4	37.9	255.9
Nov. 13th	242.6	122.9	36.3	244.3
Dec. 13th	193.1	140.9	31.6	215.3
1914				
Jan. 12th	185.0	138.7	30.5	208.1
Feb. 11th	180.1	163.6	31.6	216.6
Mar. 13th	176.9	132.7	29.8	190.0
Apr. 12th	210.4	138.2	34.3	216.3
May 12th	261.0	156.6	40.6	260.4
June 11th	309.6	157.8	45.7	294.8
July 11th	315.2	157.6	46.4	298.5
Aug. 10th	324.8	158.4	48.1	315.3
Sep. 9th	369.3	158.3	53.28	355.0
Oct. 9th	372.3	139.5	53.5	356.9
Nov. 8th	296.3	161.1	49.4	301.2
Dec. 8th	308.2	154.1	50.9	305.0
1915				
Jan. 7th	280.1	148.5	49.0	279.2
Feb. 6th	262.9	143.4	47.82	267.8
Mar. 8th	251.7	137.2	44.4	258.5
Apr. 7th	228.1	132.4	40.9	238.5
May 7th	217.1	126.1	38.8	227.2
June 6th	228.6	153.2	42.7	248.7
July 6th	251.2	242.0	53.3	310.7
Aug. 5th	336.6	206.5	61.4	360.2
Sep. 4th	383.9	191.9	66.3	389.3
Oct. 4th	397.9	198.9	65.3	404.7
Nov. 3rd	388.0	194.0	62.5	398.2
Dec. 3rd	369.9	184.9	59.1	379.6
1916				
Jan. 2nd	363.1	181.5	56.5	367.2

TABLE VIII. a.

Cow No. 563.

Total Grain, Hay, and Nutrients Fed During Each Thirty-Day

Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	180	184	29.3	223.9
Oct. 19th	180	202	30.4	232.4
Nov. 18th	180	217	31.2	239.5
Dec. 18th	184	233	32.7	249.7
1913				
Jan. 17th	180	256	33.7	257.5
Feb. 16th	140	300	31.9	248.2
Mar. 18th	120	312	30.5	238.8
Apr. 17th	154	316	34.3	266.3
May 17th	180	304	36.4	280.3
June 16th	140	299	32.7	248.0
July 16th	94	268.5	26.3	198:9
Aug. 15th	60	326.5	27.4	204.2
Sep. 14th	60	300	26.6	192.9
Oct. 14th	60	300	26.6	200.3
Nov. 13th	70	300	27.8	237.8
Dec. 13th	120	300	33.5	237.7
1914				
Jan. 12th	120	300	33.4	237.7
Feb. 11th	120	300	33.4	231.5
Mar. 13th	120	300	33.9	231.5
Apr. 12th	120	300	33.9	231.2
May 12th	120	300	33.4	229.6
June 11th	118	300	33.0	231.0
July 11th	120	300	33.2	234.9
Aug. 10th	120	298	33.6	239.1
Sep. 9th	120	300	33.9	238.8
Oct. 9th	120	300	33.9	237.0
Nov. 8th	120	300	35.8	238.3
Dec. 8th	145.5	300	40.0	254.3
1915				
Jan. 7th	210	300	52.9	300.1
Feb. 6th	200.5	300	52.3	294.9
Mar. 8th	210	300	53.3	304.0
Apr. 7th	189.5	300	50.6	288.6
May 7th	139	300	44.1	249.7
June 6th	120	300	41.7	235.1
July 6th	68	300	34.6	197.7
Aug. 5th	60	342	37.0	213.4
Sep. 4th	60	360	38.5	222.2
Oct. 4th	71	304	29.1	204.6
Nov. 3rd	90	300	32.7	267.3
Dec. 3rd	90	300	33.4	216.4
1916				
Jan. 2nd	90	300	33.1	215.0

TABLE VIII. b.

Cow No. 563.

Grain, Hay, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	310.8	317.7	50.6	386.6
Oct. 19th	285.2	320.1	48.1	368.3
Nov. 18th	267.4	322.4	46.3	355.8
Dec. 18th	258.4	327.2	55.9	350.8
1913				
Jan. 17th	237.4	337.7	44.4	339.7
Feb. 16th	175.4	375.9	39.9	311.0
Mar. 18th	145.9	379.5	37.1	290.5
Apr. 17th	182.2	373.9	40.5	315.1
May 17th	204.3	345.0	41.3	318.1
June 16th	155.3	331.8	36.2	275.2
July 16th	105.8	302.3	29.6	223.9
Aug. 15th	68.1	371.0	31.1	232.0
Sep. 14th	68.6	343.2	30.4	220.7
Oct. 14th	68.3	341.6	30.2	228.1
Nov. 13th	78.6	337.0	31.2	267.1
Dec. 13th	131.8	329.6	36.8	261.2
1914				
Jan. 12th	128.6	321.5	35.7	254.7
Feb. 11th	125.0	312.5	34.7	241.1
Mar. 13th	123.2	308.0	34.8	237.6
Apr. 12th	120.2	300.6	33.9	231.6
May 12th	118.2	295.5	32.9	226.2
June 11th	113.7	289.2	31.8	222.7
July 11th	113.3	283.2	31.3	221.8
Aug. 10th	111.7	277.4	31.2	222.6
Sep. 9th	110.2	275.7	31.1	219.4
Oct. 9th	104.4	261.0	29.4	206.2
Nov. 8th	106.1	265.2	31.6	210.6
Dec. 8th	147.7	304.5	40.6	258.1
1915				
Jan. 7th	216.4	309.2	54.5	309.2
Feb. 6th	205.8	308.0	53.6	302.8
Mar. 8th	190.4	301.5	53.5	305.5
Apr. 7th	188.5	298.5	50.3	287.1
May 7th	138.7	299.4	44.0	249.2
June 6th	120.4	301.2	41.8	236.0
July 6th	68.7	303.3	34.9	199.8
Aug. 5th	61.3	349.6	37.8	218.2
Sep. 4th	60.4	362.9	38.8	223.9
Oct. 4th	71.4	305.8	29.2	205.8
Nov. 3rd	91.6	305.4	33.2	272.1
Dec. 3rd	91.3	304.5	33.9	219.6
1916				
Jan. 2nd	90.8	302.4	33.1	216.7

TABLE IX. a.

Cow No. 564.

Total Grain, Hay, and Nutrients Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	180	277	34.6	268.1
Oct. 19th	180	265	34.0	262.3
Nov. 18th	180	270	34.2	264.7
Dec. 18th	180	300	36.1	278.6
1913				
Jan. 17th	180	320	37.3	287.9
Feb. 16th	140	360	35.4	276.6
Mar. 18th	120	360	33.2	261.6
Apr. 17th	154	360	36.8	287.3
May 17th	180	358	39.5	305.9
June 16th	140	394	38.2	293.7
July 16th	22	414	26.2	213.4
Aug. 15th	0	420	26.3	204.1
Sep. 14th	0	418	27.3	205.4
Oct. 14th	0	414	27.1	203.4
Nov. 13th	100	326	32.9	235.8
Dec. 13th	210	300	43.9	306.0
1914				
Jan. 12th	286	300	52.7	363.6
Feb. 11th	252	351	52.1	362.8
Mar. 13th	256	360	54.0	357.0
Apr. 12th	300	360	59.4	388.1
May 12th	284	360	56.5	376.0
June 11th	233	360	50.1	339.7
July 11th	171	287	38.2	260.5
Aug. 10th	167	300	39.1	269.9
Sep. 9th	120	300	33.9	239.1
Oct. 9th	120	300	33.9	238.8
Nov. 8th	120	300	35.8	238.3
Dec. 8th	120	300	36.6	235.2
1915				
Jan. 7th	186	300	30.6	263.6
Feb. 6th	275	330	45.1	365.8
Mar. 8th	270	420	43.7	407.2
Apr. 7th	270	379	43.5	388.1
May 7th	226.5	360	60.6	345.6
June 6th	129.5	341	46.5	262.0
July 6th	150	360	50.4	289.9
Aug. 5th	129.5	360	47.6	275.7
Sep. 4th	120	360	46.3	268.4
Oct. 4th	90.5	360	35.3	247.3
Nov. 3rd	90	360	37.0	246.3
Dec. 3rd	90	360	37.9	245.6
1916				
Jan. 2nd	90	360	37.6	244.2

TABLE IX. b.

Cow No. 564.

Grain, Hay, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	242.2	372.8	46.5	360.8
Oct. 19th	231.0	340.1	43.6	336.7
Nov. 18th	224.1	336.2	42.5	329.6
Dec. 18th	213.5	355.8	42.8	330.4
1913				
Jan. 17th	203.8	362.4	42.2	326.0
Feb. 16th	152.6	392.5	38.6	301.6
Mar. 18th	127.7	383.3	35.3	278.5
Apr. 17th	160.0	374.3	38.2	298.6
May 17th	177.8	353.7	39.0	302.2
June 16th	131.9	370.9	35.9	276.0
July 16th	207.1	389.8	24.6	200.9
Aug. 15th	0	405.7	25.4	197.1
Sep. 14th	0	409.4	26.7	201.1
Oct. 14th	0	427.6	27.9	210.1
Nov. 13th	124.5	405.9	40.9	293.6
Dec. 13th	264.8	378.3	55.3	385.8
1914				
Jan. 12th	355.7	373.1	65.5	452.4
Feb. 11th	306.1	426.4	63.3	440.8
Mar. 13th	304.7	428.5	64.2	425.0
Apr. 12th	346.4	415.7	68.5	448.1
May 12th	322.7	409.0	64.2	427.3
June 11th	253.2	391.3	54.4	369.2
July 11th	185.8	311.9	41.5	283.1
Aug. 10th	172.5	309.9	40.3	278.8
Sep. 9th	122.6	306.7	34.6	244.4
Oct. 9th	121.4	303.6	34.3	241.7
Nov. 8th	119.7	299.4	35.7	237.8
Dec. 8th	117.6	294.1	35.8	230.5
1915				
Jan. 7th	214.0	385.2	35.2	303.3
Feb. 6th	322.3	386.8	52.8	428.8
Mar. 8th	301.0	468.2	48.7	453.9
Apr. 7th	294.4	413.3	47.4	423.2
May 7th	245.6	390.4	65.7	374.8
June 6th	144.2	379.7	51.7	291.8
July 6th	169.1	405.8	56.8	326.8
Aug. 5th	146.4	407.2	53.8	311.8
Sep. 4th	131.4	394.3	50.7	293.9
Oct. 4th	96.4	383.7	37.6	263.6
Nov. 3rd	95.4	381.7	39.2	261.1
Dec. 3rd	93.1	372.6	39.2	254.2
1916				
Jan. 2nd	90.4	361.8	37.7	245.4

TABLE X. a.

Cow No. 565.

Total Grain, Hay, and Nutrients Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	176	234	31.8	244.6
Oct. 19th	165	270	32.7	253.4
Nov. 18th	166	261	32.3	249.8
Dec. 18th	180	300	36.1	278.6
1913				
Jan. 17th	180	322	37.4	288.8
Feb. 16th	140	338	34.1	266.2
Mar. 18th	155	167	25.9	196.3
Apr. 17th	257	168	36.7	273.7
May 17th	350	140	44.9	330.6
June 16th	296	201	44.9	319.6
July 16th	220	240	39.4	280.9
Aug. 15th	132	288	33.5	240.2
Sep. 14th	120	300	33.6	238.4
Oct. 14th	120	300	33.6	238.4
Nov. 13th	120	300	33.6	238.2
Dec. 13th	120	300	33.5	237.8
1914				
Jan. 12th	120	300	33.4	237.7
Feb. 11th	120	298	33.3	236.7
Mar. 13th	120	300	33.9	231.5
Apr. 12th	120	300	33.9	231.5
May 12th	120	300	33.4	231.5
June 11th	145	300	36.1	248.6
July 11th	180	300	40.1	273.2
Aug. 10th	180	300	40.6	279.6
Sep. 9th	180	300	40.9	283.9
Oct. 9th	180	300	40.8	283.5
Nov. 8th	180	300	43.7	283.2
Dec. 8th	180	300	44.5	280.0
1915				
Jan. 7th	180	300	49.0	277.7
Feb. 6th	180	300	49.6	279.4
Mar. 8th	180	300	49.4	281.0
Apr. 7th	159.5	300	46.7	265.5
May 7th	120	300	41.7	235.1
June 6th	120	300	41.7	235.1
July 6th	120	300	41.4	237.8
Aug. 5th	100	342	42.2	244.2
Sep. 4th	128.5	360	47.5	275.0
Oct. 4th	120.5	360	39.3	270.4
Nov. 3rd	119.5	360	40.7	274.4
Dec. 3rd	120	357.5	41.4	267.8
1916				
Jan. 2nd	120	360	41.1	267.2

TABLE X. b.

Cow No. 565.

Grain, Hay, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	277.6	369.0	50.1	385.8
Oct. 19th	241.2	394.7	47.8	370.4
Nov. 18th	230.9	375.5	46.4	358.8
Dec. 18th	247.2	412.0	49.5	382.6
1913				
Jan. 17th	239.0	427.6	49.6	383.5
Feb. 16th	180.6	436.4	44.0	343.4
Mar. 18th	214.9	231.6	35.9	272.2
Apr. 17th	369.2	241.3	52.7	393.2
May 17th	481.5	223.2	61.8	455.0
June 16th	391.5	265.8	59.3	422.7
July 16th	281.6	307.2	50.4	359.6
Aug. 15th	167.5	365.4	42.5	304.8
Sep. 14th	149.4	373.5	41.8	296.8
Oct. 14th	145.9	364.9	40.8	290.0
Nov. 13th	143.1	357.9	38.0	284.2
Dec. 13th	139.2	348.0	38.8	275.8
1914				
Jan. 12th	134.2	335.5	37.3	265.8
Feb. 11th	130.5	324.2	36.2	257.5
Mar. 13th	127.7	319.4	36.1	246.5
Apr. 12th	122.9	307.3	34.7	237.1
May 12th	120.2	300.6	33.4	231.9
June 11th	151.6	313.8	37.7	260.0
July 11th	205.4	342.4	45.7	311.8
Aug. 10th	203.6	339.3	45.9	316.2
Sep. 9th	203.8	339.7	46.3	321.5
Oct. 9th	205.2	342.0	46.5	323.2
Nov. 8th	204.0	340.1	49.5	321.0
Dec. 8th	200.4	334.0	49.5	311.4
1915				
Jan. 7th	199.1	331.8	54.2	307.1
Feb. 6th	192.9	321.5	53.1	299.4
Mar. 8th	185.3	308.9	50.8	289.3
Apr. 7th	158.0	297.3	46.2	263.1
May 7th	116.7	291.8	40.5	228.6
June 6th	113.1	282.7	39.3	221.5
July 6th	120.2	300.5	41.4	238.2
Aug. 5th	108.3	370.4	45.7	264.5
Sep. 4th	141.0	395.1	52.1	301.8
Oct. 4th	131.9	394.3	43.0	296.1
Nov. 3rd	132.0	397.7	44.9	303.2
Dec. 3rd	132.5	395.0	45.7	295.9
1916				
Jan. 2nd	132.4	397.3	45.3	294.9

TABLE XI. a.

Cow No. 566.

Total Grain, Hay, and Nutrients Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	36	361	24.4	198.8
Oct. 19th	0	361	20.7	171.5
Nov. 18th	0	333	19.1	158.2
Dec. 18th	60	321	24.7	197.8
1913				
Jan. 17th	90	353	29.7	235.6
Feb. 16th	70	360	28.0	223.9
Mar. 18th	60	360	26.9	216.3
Apr. 17th	60	360	26.9	216.3
May 17th	60	360	26.9	216.3
June 16th	20	400	25.0	235.2
July 16th	0	322	18.4	153.0
Aug. 15th	0	300	18.8	145.8
Sep. 14th	0	300	19.6	147.4
Oct. 14th	0	300	19.6	147.4
Nov. 13th	56	300	26.1	189.7
Dec. 13th	266	267	48.3	332.4
1914				
Jan. 12th	356	300	60.9	416.7
Feb. 11th	312	348	58.9	406.8
Mar. 13th	300	360	59.4	388.1
Apr. 12th	282	360	57.3	375.4
May 12th	186	360	45.1	307.1
June 11th	55	372	30.4	220.5
July 11th	0	420	27.2	205.4
Aug. 10th	0	420	27.8	207.8
Sep. 9th	0	420	28.1	209.1
Oct. 9th	0	420	28.1	209.1
Nov. 8th	0	420	28.3	208.2
Dec. 8th	0	420	29.4	203.8
1915				
Jan. 7th	0	420	35.8	200.5
Feb. 6th	0	420	36.7	200.0
Mar. 8th	0	420	36.7	200.0
Apr. 7th	0	419	36.6	199.5
May 7th	0	360	31.5	171.4
June 6th	0	360	31.5	171.4
July 6th	0	306	25.3	148.2
Aug. 5th	0	300	25.6	146.6
Sep. 4th	0	300	25.6	146.6
Oct. 4th	0	300	19.5	148.0
Nov. 3rd	0	300	21.4	146.6
Dec. 3rd	0	370	27.6	180.0
1916				
Jan. 2nd	0	420	31.4	204.3

TABLE XI. b.

Cow No. 566.

Grain, Hay, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	51.2	513.5	34.7	282.7
Oct. 19th	0	507.0	29.0	240.8
Nov. 18th	0	485.4	27.8	230.6
Dec. 18th	88.7	474.8	36.5	292.5
1913				
Jan. 17th	126.9	497.8	41.8	332.2
Feb. 16th	95.4	491.1	38.1	305.4
Mar. 18th	79.2	475.5	35.5	285.7
Apr. 17th	76.9	461.5	34.4	277.3
May 17th	74.1	444.9	33.2	267.3
June 16th	23.7	475.6	29.7	279.6
July 16th	0	387.4	21.1	184.1
Aug. 15th	0	375.9	23.5	182.7
Sep. 14th	0	382.1	24.9	187.7
Oct. 14th	0	387.5	25.3	190.4
Nov. 13th	78.7	421.9	36.7	266.8
Dec. 13th	389.4	390.9	70.7	486.6
1914				
Jan. 12th	487.0	410.3	83.3	570.0
Feb. 11th	402.5	449.0	76.0	524.9
Mar. 13th	375.9	451.1	74.4	486.3
Apr. 12th	337.7	430.1	68.6	449.5
May 12th	219.8	425.5	53.3	363.0
June 11th	65.3	442.3	36.1	262.1
July 11th	0	494.6	32.0	241.9
Aug. 10th	0	496.4	32.8	245.6
Sep. 9th	0	500.5	33.4	249.2
Oct. 9th	0	498.2	33.3	248.0
Nov. 8th	0	492.3	33.1	244.0
Dec. 8th	0	486.1	34.0	235.8
1915				
Jan. 7th	0	488.9	41.6	233.4
Feb. 6th	0	483.8	42.2	230.4
Mar. 8th	0	480.0	41.9	228.5
Apr. 7th	0	473.9	41.4	225.6
May 7th	0	407.2	35.6	194.1
June 6th	0	410.0	35.8	195.2
July 6th	0	359.5	29.7	174.0
Aug. 5th	0	356.7	30.4	174.3
Sep. 4th	0	358.8	30.6	175.3
Oct. 4th	0	355.0	23.0	175.1
Nov. 3rd	0	350.5	25.7	176.0
Dec. 3rd	0	442.0	32.9	215.
1916				
Jan. 2nd	0	486.1	36.3	236.4

TABLE XII. a.

Cow No. 567.

Total Grain, Hay, and Nutrients Fed During Each Thirty-Day Period of the Experiment.

(Amount in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	36	217	16.2	130.4
Oct. 19th	0	213	12.2	101.2
Nov. 18th	0	256	14.6	121.6
Dec. 18th	60	280	22.3	178.3
1913				
Jan. 17th	90	292	26.2	206.7
Feb. 16th	70	300	24.5	195.4
Mar. 18th	60	300	23.5	187.8
Apr. 17th	60	336	25.5	204.9
May 17th	60	364	27.1	218.2
June 16th	60	360	27.2	216.5
July 16th	0	320	18.3	152.1
Aug. 15th	0	300	18.8	145.8
Sep. 14th	0	300	19.6	147.4
Oct. 14th	0	285	18.6	140.0
Nov. 13th	56	293	25.7	186.3
Dec. 13th	210	300	43.9	306.0
1914				
Jan. 12th	240	300	47.4	328.7
Feb. 11th	248	300	48.3	334.8
Mar. 13th	256	295	49.9	325.2
Apr. 12th	282	300	53.4	346
May 12th	186	300	41.2	277.7
June 11th	67	300	27.1	193.8
July 11th	60	300	26.3	188.9
Aug. 10th	60	300	26.8	192.2
Sep. 9th	60	300	27.0	194.2
Oct. 9th	60	300	27.0	194.1
Nov. 8th	60	300	28.0	193.5
Dec. 8th	60	300	28.8	190.4
1915				
Jan. 7th	60	300	33.4	188.0
Feb. 6th	60	300	34.0	188.4
Mar. 8th	60	300	34.0	189.9
Apr. 7th	19	340.5	32.2	176.8
May 7th	0	330	27.7	157.1
June 6th	0	330	27.7	157.1
July 6th	0	303	26.1	146.8
Aug. 5th	101	300	38.8	224.4
Sep. 4th	180	300	49.0	285.3
Oct. 4th	177	300	42.8	284.3
Nov. 3rd	180	294	43.6	284.4
Dec. 3rd	180	331	46.8	301.9
1916				
Jan. 2nd	131	360	42.4	275.7

TABLE XII. b.

Cow No. 567.

Grain, Hay, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	62.5	376.7	28.1	226.3
Oct. 19th	0	375.6	21.5	178.4
Nov. 18th	0	461.2	26.2	210.9
Dec. 18th	107.7	502.6	40.0	371.0
1913				
Jan. 17th	153.3	497.4	44.6	352.1
Feb. 16th	117.8	505.0	41.2	328.9
Mar. 18th	99.1	495.8	38.8	310.4
Apr. 17th	96.3	539.3	40.9	328.8
May 17th	92.1	559.1	41.6	335.1
June 16th	87.5	525.5	39.7	316.0
July 16th	0	461.7	26.4	219.4
Aug. 15th	0	443.1	27.7	215.3
Sep. 14th	0	446.4	29.1	219.3
Oct. 14th	0	429.8	28.0	211.1
Nov. 13th	83.4	436.6	38.3	277.6
Dec. 13th	354.7	506.7	74.1	516.8
1914				
Jan. 12th	387.7	484.6	76.5	531.0
Feb. 11th	381.5	461.5	74.3	515.0
Mar. 13th	384.9	443.6	75.0	489.0
Apr. 12th	400.5	426.1	75.8	491.4
May 12th	260.8	420.7	57.7	389.4
June 11th	95.9	429.7	38.8	277.6
July 11th	85.9	429.7	37.6	270.5
Aug. 10th	85.7	428.5	38.2	274.5
Sep. 9th	85.7	428.5	38.5	277.4
Oct. 9th	85.2	426.1	38.3	275.7
Nov. 8th	83.6	418.4	39.0	269.8
Dec. 8th	81.8	409.2	39.2	259.7
1915				
Jan. 7th	81.3	406.5	45.2	254.7
Feb. 6th	79.1	395.7	44.8	248.5
Mar. 8th	76.5	382.6	43.3	242.2
Apr. 7th	74.7	424.0	40.0	220.2
May 7th	0	407.4	34.1	193.9
June 6th	0	404.4	33.9	192.4
July 6th	0	381.6	32.8	184.8
Aug. 5th	140.6	417.8	54.0	312.5
Sep. 4th	253.5	422.5	69.0	401.8
Oct. 4th	240.4	407.6	58.1	386.2
Nov. 3rd	236.8	386.8	57.3	374.2
Dec. 3rd	230.4	423.8	59.9	386.5
1916				
Jan. 2nd	159.7	429.0	51.6	336.2

TABLE XIII. a.

Cow No. 568.

Total Grain, Hay, and Nutrients Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	36	274	19.4	157.5
Oct. 19th	0	298	17.0	141.6
Nov. 18th	0	326	18.7	154.9
Dec. 18th	60	355	26.6	214.0
1913				
Jan. 17th	90	339	28.9	229.0
Feb. 16th	70	322	25.8	205.8
Mar. 18th	60	338	25.7	205.9
Apr. 17th	60	360	26.9	216.3
May 17th	60	360	26.9	216.3
June 16th	20	377	23.7	194.2
July 16th	0	320	18.3	152.1
Aug. 15th	0	300	18.8	145.8
Sep. 14th	0	300	19.6	147.4
Oct. 14th	0	300	19.6	147.4
Nov. 13th	56	297	25.9	188.2
Dec. 13th	210	300	43.9	306.0
1914				
Jan. 12th	240	300	47.4	328.7
Feb. 11th	248	348	51.4	358.3
Mar. 13th	256	342	53.0	348.2
Apr. 12th	276	303	52.8	343.3
May 12th	186	360	45.1	307.1
June 11th	14	413	28.4	211.8
July 11th	0	420	27.2	205.4
Aug. 10th	4	414	27.8	207.8
Sep. 9th	1	416	27.9	207.8
Oct. 9th	0	420	28.1	209.1
Nov. 8th	0	420	28.3	208.2
Dec. 8th	0	420	29.4	203.8
1915				
Jan. 7th	53	367	38.0	187.7
Feb. 6th	81	360	42.0	233.0
Mar. 8th	120	360	46.9	263.5
Apr. 7th	120	360	46.9	263.7
May 7th	88	342	41.2	230.5
June 6th	60	300	33.9	203.3
July 6th	56	300	33.1	188.5
Aug. 5th	0	300	25.6	146.6
Sep. 4th	0	300	25.6	146.6
Oct. 4th	0	300	19.5	148.0
Nov. 3rd	0	300	21.4	146.6
Dec. 3rd	0	386	28.8	187.7
1916				
Jan. 2nd	0	420	31.4	204.4

TABLE XIII. b.

Cow No. 568.

Grain, Hay, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Grain	Hay	Protein	Total Nutrients
1912				
Sep. 19th	55.8	424.8	30.0	244.1
Oct. 19th	0	454.9	25.9	216.1
Nov. 18th	0	498.4	28.5	236.8
Dec. 18th	92.3	546.1	40.9	329.2
1913				
Jan. 17th	135.7	511.3	43.5	345.3
Feb. 16th	103.5	476.3	38.1	304.4
Mar. 18th	85.9	484.2	36.8	294.9
Apr. 17th	84.3	506.3	37.8	304.2
May 17th	82.1	493.1	36.8	296.3
June 16th	26.1	493.4	31.0	254.1
July 16th	0	413.9	23.6	196.7
Aug. 15th	0	396.2	24.8	192.6
Sep. 14th	0	407.2	26.5	200.0
Oct. 14th	0	417.8	27.2	205.2
Nov. 13th	78.2	414.8	36.1	262.8
Dec. 13th	314.8	449.7	65.8	458.7
1914				
Jan. 12th	363.0	453.8	71.7	497.2
Feb. 11th	350.7	492.2	72.7	506.7
Mar. 13th	340.4	454.7	70.4	463.0
Apr. 12th	352.0	386.4	67.3	437.8
May 12th	229.0	443.3	55.5	378.2
June 11th	16.7	492.8	33.8	252.7
July 11th	0	504.8	32.6	246.8
Aug. 10th		595.2	33.2	248.5
Sep. 9th		500.1	33.5	249.7
Oct. 9th	0	504.2	33.9	251.0
Nov. 8th	0	495.2	33.3	245.5
Dec. 8th	0	486.6	34.0	236.1
1915				
Jan. 7th	72.2	572.1	51.7	255.7
Feb. 6th	109.6	487.1	56.8	315.2
Mar. 8th	157.2	471.8	61.4	345.3
Apr. 7th	154.0	462.1	60.2	338.5
May 7th	112.9	439.0	52.8	289.5
June 6th	75.4	377.3	42.6	255.7
July 6th	71.2	381.6	42.1	239.8
Aug. 5th	0	386.5	32.9	188.9
Sep. 4th	0	396.4	33.8	193.6
Oct. 4th	0	397.8	25.8	197.6
Nov. 3rd	0	402.6	28.7	196.7
Dec. 3rd	0	523.7	38.9	254.6
1916				
Jan. 2nd	0	560.0	41.8	277.5

TABLE XIV. a.

Lot I.

Average Amounts of Hay, Grain, and Nutrients Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Hay	Grain	Protein	Total Nutrients
1912				
Sep. 19th	193.3	340.33	46.6	349.83
Oct. 19th	177.17	412.33	53.2	396.7
Nov. 18th	186.5	413.67	53.87	402.13
Dec. 18th	194.33	402.33	53.4	396.37
1913				
Jan. 17th	196.67	416.33	55.13	407.57
Feb. 16th	189.67	475.33	60.93	448.77
Mar. 18th	186.67	487.0	62.03	456.13
Apr. 17th	193.17	453.0	58.8	433.57
May 17th	204.83	481.0	62.43	460.27
June 16th	203.0	472.17	64.8	453.8
July 16th	177.17	387	55.2	377.7
Aug. 15th	202.33	338.17	52.07	354.9
Sep. 14th	161.0	298.27	45.27	305.3
Oct. 14th	# 139	# 240.5	# 37.05	# 250.7
Nov. 13th	150.25	249.75	38.9	263.15
Dec. 13th	180	221	37.45	255.6
1914				
Jan. 12th	180	240	39.6	270.0
Feb. 11th	211	240	41.65	285.2
Mar. 13th	180	240	40.5	257.7
Apr. 12th	175.5	250.5	41.55	262.9
May 12th	180	270	43.2	278.1
June 11th	180	296.5	45.7	296.7
July 11th	180	300	46.1	298.85
Aug. 10th	180	306.5	47.45	312.45
Sep. 9th	180	329	50.05	335.65
Oct. 9th	180	330	50.05	335.55
Nov. 8th	180	300.5	51.25	313.7
Dec. 8th	180	360.75	59.55	356.45
1915				
Jan. 7th	180	364.75	62.8	357.85
Feb. 6th	180	360	63.2	358.85
Mar. 8th	180	360	62.15	362.0
Apr. 7th	200.5	350	62.55	364.6
May 7th	207	294.75	62.4	363.7
June 6th	218.5	290.05	56.35	327.1
July 6th	264.5	288	60.1	324.9
Aug. 5th	220.11	370.75	67.05	393.2
Sep. 4th	202.5	405	70.0	411.0
Oct. 4th	208.62	417.25	68.55	426.05
Nov. 3rd	204.12	408.25	65.85	419
Dec. 3rd	202.87	405.75	64.85	416.4
1916				
Jan. 2nd	203.87	407.75	63.5	412.35

Note # Averages for two cows only as No. 561 died.

TABLE XIV. b.

Lot I.

Hay, Grain, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Hay	Grain	Protein	Total Nutrients
1912				
Sep. 19th	286.49	504.41	69.06	518.49
Oct. 19th	234.91	546.71	70.53	525.98
Nov. 18th	231.41	513.3	66.84	498.98
Dec. 18th	236.0	488.62	64.85	481.38
1913				
Jan. 17th	226.18	478.81	63.4	468.78
Feb. 16th	205.93	516.1	66.15	487.26
Mar. 18th	190.44	496.83	63.28	465.34
Apr. 17th	189.71	444.9	57.74	425.82
May 17th	188.62	442.95	57.49	423.86
June 16th	176.16	409.76	56.23	393.82
July 16th	148.54	324.47	46.28	316.67
Aug. 15th	166.06	277.55	42.73	291.28
Sep. 14th	128.96	238.92	36.26	244.55
Oct. 14th	124.11	214.75	33.08	223.85
Nov. 13th	137.39	227.81	35.48	240.62
Dec. 13th	161.92	198.81	33.69	229.93
1914				
Jan. 12th	157.54	210.06	34.66	236.32
Feb. 11th	179.34	203.99	35.4	242.41
Mar. 13th	150.89	201.19	33.95	216.02
Apr. 7th	152.0	216.95	35.98	227.69
May 12th	162.67	244.01	39.04	251.33
June 11th	160.38	264.18	40.71	264.36
July 11th	158.18	263.64	40.51	262.63
Aug. 10th	156.78	266.96	41.32	272.14
Sep. 9th	155.21	283.69	43.15	289.42
Oct. 9th	154.57	283.38	42.92	288.14
Nov. 8th	158.89	265.27	45.24	276.92
Dec. 8th	161.78	324.24	53.52	320.37
1915				
Jan. 7th	159.65	323.53	55.7	317.41
Feb. 6th	156.3	312.6	54.88	311.6
Mar. 8th	151.63	303.26	52.35	304.94
Apr. 7th	164.3	286.81	51.25	298.78
May 7th	167.99	239.2	50.64	295.16
June 6th	181.28	240.64	46.75	271.38
July 6th	230.92	251.43	52.47	283.65
Aug. 5th	193.06	325.18	58.81	344.88
Sep. 4th	174.79	349.58	60.42	354.76
Oct. 4th	174.44	348.92	57.32	356.28
Nov. 3rd	165.88	331.84	53.51	340.5
Dec. 3rd	160.16	320.33	51.19	328.7
1916				
Jan. 2nd	155.45	310.91	48.41	314.38

TABLE XV. a.

Lot II.

Average Amounts of Hay, Grain, and Nutrients Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Hay	Grain	Protein	Total Nutrients
1912				
Sep. 19th	231.67	178.67	31.9	245.5
Oct. 19th	245.67	175	32.37	249.4
Nov. 18th	249.33	175.33	32.57	251.3
Dec. 18th	277.67	181.33	34.97	268.97
1913				
Jan. 17th	299.33	180	36.13	278.07
Feb. 16th	332.67	140	33.8	263.7
Mar. 18th	279.67	131.67	29.87	232.23
Apr. 17th	281.33	188.33	35.93	275.77
May 17th	267.33	236.67	40.27	305.6
June 16th	298	192	38.6	286.93
July 16th	307.5	112	30.63	231.07
Aug. 15th	344.83	64	29.07	216.17
Sep. 14th	339.33	60.0	29.17	212.23
Oct. 14th	338	60.0	29.10	214.03
Nov. 13th	308.67	96.67	31.43	237.27
Dec. 13th	300	150	36.97	260.5
1914				
Jan. 12th	300	175.33	39.83	279.7
Feb. 11th	316.33	164	39.6	277.0
Mar. 13th	320	165.33	40.6	273.3
Apr. 12th	320	180	42.4	283.6
May 12th	320	174.67	41.1	279.03
June 11th	320	165.33	39.8	273.1
July 11th	295.67	157	37.17	256.2
Aug. 10th	299.33	159	37.77	262.87
Sep. 9th	300	140	36.23	253.93
Oct. 9th	300	140	32.87	253.1
Nov. 8th	300	140	38.43	253.27
Dec. 8th	300	148.5	40.37	256.5
1915				
Jan. 7th	300	192	44.17	280.47
Feb. 6th	310	218.5	49.0	313.37
Mar. 8th	340	220	48.8	330.73
Apr. 7th	326.33	206.33	46.93	314.07
May 7th	320	161.83	48.8	276.80
June 6th	313.67	123.17	43.3	244.07
July 6th	320	112.67	42.13	241.8
Aug. 5th	348	96.5	42.27	244.43
Sep. 4th	360	102.83	44.1	255.2
Oct. 4th	341.33	94.0	34.57	240.77
Nov. 3rd	340	99.83	36.8	262.77
Dec. 3rd	339.17	100	37.57	243.27
1916				
Jan. 2nd	340	100	37.27	242.13

TABLE XV. b.

Lot II.

Hay, Grain, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Hay	Grain	Protein	Total Nutrients
1912				
Sep. 19th	355.37	274.07	48.93	376.59
Oct. 19th	352.01	250.74	46.38	357.78
Nov. 18th	344.42	242.2	44.99	347.14
Dec. 18th	364.73	238.18	45.93	353.3
1913				
Jan. 17th	374.96	225.5	45.26	348.37
Feb. 16th	401.14	168.81	40.75	317.97
Mar. 18th	338.03	159.21	36.02	280.7
Apr. 17th	337.2	225.72	43.07	330.61
May 17th	306.07	271.04	46.11	349.93
June 16th	328.91	211.85	42.6	316.69
July 16th	337.83	123.04	33.65	253.9
Aug. 15th	382.84	71.1	32.29	240.16
Sep. 14th	377.4	66.73	32.44	236.01
Oct. 14th	380.07	66.33	32.35	237.96
Nov. 13th	367.32	115.06	25.46	282.36
Dec. 13th	350.79	175.39	43.22	304.6
1914				
Jan. 12th	342.19	199.95	45.43	319.03
Feb. 11th	351.09	182.03	43.95	307.47
Mar. 13th	348.73	180.14	44.24	297.51
Apr. 12th	338.01	190.13	44.78	299.56
May. 12th	331.04	181.13	42.62	289.32
June 11th	329.48	170.23	40.56	281.19
July 11th	310.73	165.02	39.06	269.25
Aug. 10th	306.78	162.97	38.71	269.44
Sep. 9th	305.31	142.47	36.87	258.39
Oct. 9th	303.09	141.44	33.2	255.7
Nov. 8th	298.54	139.31	38.24	252.06
Dec. 8th	310.04	153.47	41.72	265.08
1915				
Jan. 7th	328.15	210.01	48.31	306.82
Feb. 6th	337.02	237.55	53.27	340.72
Mar. 8th	356.24	230.51	51.11	346.5
Apr. 7th	333.6	211.09	48.02	321.36
May 7th	325.1	164.38	49.57	281.21
June 6th	318.47	125.06	43.96	247.84
July 6th	334.06	117.65	43.98	252.42
Aug. 5th	374.87	103.98	45.54	263.36
Sep. 4th	384.36	109.75	47.08	272.47
Oct. 4th	359.9	99.12	36.45	253.92
Nov. 3rd	360.43	105.83	39.01	278.59
Dec. 3rd	356.26	105.03	39.49	255.53
1916				
Jan. 2nd	352.51	103.68	38.64	251.01

TABLE XVI. a.

Lot III.

Average Amounts of Hay, Grain, and Nutrients Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Hay	Grain	Protein	Total Nutrients
1912				
Sep. 19th	284	36	20	162.23
Oct. 19th	290.67	0	16.63	138.1
Nov. 18th	305	0	14.13	144.9
Dec. 18th	318.67	60	24.53	196.7
1913				
Jan. 17th	328	90	28.27	223.8
Feb. 16th	327.33	70	26.1	208.37
Mar. 18th	332.67	60	25.37	203.3
Apr. 17th	352	60	26.43	212.5
May 17th	361.33	60	26.97	216.93
June 16th	379	33.33	25.3	215.3
July 16th	320.67	0	18.33	152.4
Aug. 15th	300	0	18.8	145.8
Sep. 14th	300	0	19.6	147.4
Oct. 14th	295	0	19.27	144.9
Nov. 13th	296.67	56	25.9	188.07
Dec. 13th	289	228.67	45.37	314.8
1914				
Jan. 12th	300	278.67	51.9	358.03
Feb. 11th	332	269.33	52.87	366.63
Mar. 13th	332.33	270.67	54.1	353.8
Apr. 12th	321	280	54.5	354.9
May 12th	340	186	43.8	297.3
June 11th	361.67	45.33	26.63	208.7
July 11th	380	20	26.9	199.9
Aug. 10th	378	21.33	27.47	202.6
Sep. 9th	378.67	20.33	27.67	203.4
Oct. 9th	380	20	27.73	204.1
Nov. 8th	380	20	28.2	203.3
Dec. 8th	380	20	29.2	199.33
1915				
Jan. 7th	362.33	37.67	35.73	192.07
Feb. 6th	360	47	37.56	207.13
Mar. 8th	360	60	39.2	217.8
Apr. 7th	373.17	46.33	38.53	213.3
May 7th	344	29.33	33.47	186.3
June 6th	330	20	31.03	177.27
July 6th	303	18.67	28.17	161.17
Aug. 5th	300	33.67	30.0	172.53
Sep. 4th	300	60	33.4	192.83
Oct. 4th	300	59	27.27	193.43
Nov. 3rd	298	60	28.8	192.53
Dec. 3rd	362.33	60	34.4	223.2
1916				
Jan. 2nd	400	43.67	35.2	228.13

TABLE XVI. b.

Lot III.

Hay, Grain, and Nutrients per 1000 lbs. Live Weight Fed During Each Thirty-Day Period of the Experiment.

(Amounts in Pounds)

Period Ending	Hay	Grain	Protein	Total Nutrients
1912				
Sep. 19th	442.91	56.14	31.19	253.49
Oct. 19th	450.9	0	25.79	214.2
Nov. 18th	482.9	0	22.37	229.41
Dec. 18th	507.8	95.6	39.08	313.41
1913				
Jan. 17th	502.37	137.84	43.29	342.77
Feb. 16th	490.19	104.83	39.08	312.11
Mar. 18th	484.63	87.39	36.95	296.13
Apr. 17th	499.64	85.16	37.47	301.63
May 17th	495.06	82.21	36.95	297.2
June 16th	396.46	43.62	33.14	282.02
July 16th	418.79	0	23.93	199.03
Aug. 15th	403.3	0	25.27	196.02
Sep. 14th	410.21	0	26.8	201.55
Oct. 14th	410.63	0	26.82	201.69
Nov. 13th	424.06	80.04	37.02	268.86
Dec. 13th	446.46	353.29	70.09	486.32
1914				
Jan. 12th	447.42	415.62	77.4	533.97
Feb. 11th	467.21	379.02	74.41	515.9
Mar. 13th	450.37	366.85	73.31	479.46
Apr. 12th	414.67	361.71	70.4	458.46
May 12th	430.05	235.26	55.4	376.04
June 11th	456.8	57.21	36.15	263.57
July 11th	479.37	25.23	33.93	252.17
Aug. 10th	476.01	26.86	34.59	255.13
Sep. 9th	479.08	25.72	35.07	257.33
Oct. 9th	478.95	25.2	34.95	257.24
Nov. 8th	471.23	24.8	34.97	252.1
Dec. 8th	463.41	24.39	35.6	243.04
1915				
Jan. 7th	466.38	48.48	45.95	247.26
Feb. 6th	456.62	59.61	47.69	263.06
Mar. 8th	445.88	74.31	41.85	270.00
Apr. 7th	454.07	56.33	46.84	259.51
May 7th	414.7	35.35	40.34	224.59
June 6th	397.78	24.10	37.38	213.71
July 6th	373.78	23.04	34.76	198.91
Aug. 5th	385.35	43.25	38.53	221.57
Sep. 4th	390.67	78.13	43.49	251.07
Oct. 4th	385.45	75.80	35.07	248.49
Nov. 3rd	382.44	77.0	36.96	247.08
Dec. 3rd	461.41	76.41	43.81	284.25
1916				
Jan. 2nd	493.03	53.83	43.38	281.19

TABLE XVII.

ORTS PER COW FOR EACH THIRTY DAY PERIOD.

(Amounts in Pounds.)

Period Ending	Cow 560	Cow 561	Cow 562	Avg. Lot 1	Cow 563	Cow 564	Cow 565	Avg. Lot 2	Cow 566	Cow 567	Cow 568	Avg. Lot 3
1912												
Sep.19	.85	.95	1.20	1.00	1.35	.25	1.70	1.10	.10	2.60	.10	.93
Oct.19	4.80	2.60	12.40	6.60	3.95	4.70	6.30	4.98	4.30	8.40	.70	4.47
Nov.18	2.35	.70	9.25	4.10	2.35	0	0	.78	2.50	3.00	.40	1.97
Dec.18	16.90	2.15	12.20	10.42	4.90	0	0	1.63	.35	2.90	.80	1.35
Jan.17	7.50	5.80	9.55	7.62	.35	0	.45	.27	0	1.90	1.80	1.23
Feb.16	19.90	20.70	23.10	21.23	6.40	4.50	10.00	6.97	1.50	16.50	7.10	8.37
Mar.18	18.30	33.50	38.70	30.17	4.95	0	10.80	5.25	0	8.30	1.30	3.20
Apr.17	60.55	40.50	64.40	58.48	11.20	0	4.00	5.07	0	9.40	4.90	4.77
May 17	20.35	39.75	44.65	34.92	22.70	0	0	7.57	0	10.90	8.90	6.60
Jun 16	12.00	8.00	26.20	15.40	13.95	.40	5.80	6.72	0	3.50	6.20	3.23
Jul.16	3.45	.50	8.70	4.22	5.25	3.15	1.30	3.23	0	.30	0.00	.10
Aug.15	4.90	7.60	4.30	5.60	4.90	0	1.50	2.13	0	.05	.06	.04
Sep.14	6.80	1.60	7.70	5.37	1.05	.35	3.65	1.68	0	0	0	0
Oct.14	8.90	.50	.10	3.17	0	0	.15	.50	0	1.10	0	.37
Nov.13	30.65	Died	7.30	12.55	7.40	1.00	15.50	7.97	15.75	4.80	1.45	7.33
Dec.13	6.90		.50	3.70	4.70	0	0	1.57	4.30	.60	0	1.63
1914												
Jan.12	0		0	0	0	0	0	0	0	0	0	0
Feb.11	1.40		3.00	2.20	0	0	0	0	0	4.00	1.20	1.73
Mar.13	0		0	0	0	0	0	0	0	0	0	0
Apr.12	0		0	0	0	0	0	0	0	0.00	0	0.07
May 12	0		0	0	0	0	0	0	0	.20	0	.07
Jun.11	4.00		0	2.00	.50	7.30	0	2.60	0	0	1.30	.43
Jul.11	.20		0	.10	1.40	1.20	0	.87	0	0	0	0
Aug.10	0		0	0	.70	0	0	.23	.20	.50	1.80	.83
Sep. 9	0		0	0	0	0	0	0	0	0	0	0
Oct. 9	0		0	0	0	0	0	0	0	0	0	0

TABLE XVII. (Cont.)

ORTS PER COW FOR EACH THIRTY DAY PERIOD.

(Amounts in Pounds.)

Period Ending	Cow 560	Cow 561	Cow 562	Avg. Lot 1	Cow 563	Cow 564	Cow 565	Avg. Lot 2	Cow 566	Cow 567	Cow 568	Avg. Lot 3.
1914												
Nov. 8	21.31		2.40	11.85	.80	0	0	.27	0	0	0	0
Dec.8	.36		2.00	1.18	9.40	0	0	3.13	0	0	.50	.17
1915												
Jan. 7	0		0	0	0	0	0	0	0	0	0	0
Feb. 6	0		0	0	0	0	0	0	0	0	0	0
Mar. 8	0		0	0	0	0	0	0	0	0	0	0
Apr. 7	0		0	0	0	0	0	0	0	0	0	0
May 7	0		8.40	4.20	0	19.00	0	6.33	0	0	3.00	1.00
Jun. 6	2.90		5.60	4.25	0	0	0	0	0	0	6.00	2.00
Jul. 6	0		0	0	0	0	0	0	0	0	0	0
Aug. 5	0		0	0	0	0	0	0	0	0	0	0
Sep. 4	0		0	0	0	0	0	0	0	0	0	0
Oct. 4	0		0	0	0	0	0	0	0	0	0	0
Nov. 3	0		0	0	.15	0	0	.05	0	.15	0	.05
Dec. 3	0		0	0	.55	0	0	.18	0	.30	.20	.17
1916												
Jan. 2	.20		0	.10	0	0	0	0	0	0	.20	.07

TABLE XVIII.

Average Analysis of Orts.

	Percent.
Protein..................	10.589
Water....................	8.400
Fat......................	2.144
Ash......................	15.478
Crude Fiber..............	24.060
Nitrogen Free Extract.....	36.723

TABLE XIX.

Coefficients of Digestibility Used. #

	Crude Protein	Fiber	N. F. Extract	Fat
	%	%	%	%
Corn Meal	74	57	94	93
Wheat Bran	78	31	72	68
Linseed Meal	89	57	78	89
Oat Straw	28	60	51	39
Alfalfa	71	43	72	38

Note # Taken from Henry & Morrison's "Feeds and Feeding."

SALT CONSUMED.

The difference in the amount of salt consumed by the different lots is of interest. The amount consumed by each cow and the average for each lot is recorded in Table XX. The average for Lot I. is computed from the amounts consumed by only two cows since cow No. 561 did not finish the test. It is seen that the cows' appetites for salt was very markedly affected by the amount of feed which they were receiving, the cows receiving the smallest amount of feed eating the largest amount of salt. The average amount consumed by Lot II. was 34.42 lbs., a little more than twice that of Lot I. which averaged 15.75 lbs.; while Lot III. consumed 61.07 lbs., approximately four times as much as Lot I.

Several investigators[1] have reported feeding experiments in which the amount of salt consumed by cattle was apparently affected by the character of the ration. Babcock[2], in reporting his own and Carlisle's investigations on the salt requirements of dairy cows, states that the requirements will vary in different localities. His basis for this statement evidently is the fact that the salt content of feeds will vary with the character of the soil

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1. Wisconsin Research Bulletin No. 17.
   Illinois Bulletin No. 111.
   The Industrialist, Feb. 26th, 1901.

2. Wis. Report 1905, pp 129 - 156.

TABLE XX.

Salt Consumed.

Cow No.	Salt Pounds	Cow No.	Salt Pounds	Cow No.	Salt Pounds
560	15.55	563	29.75	566	70.5
561	4.55	564	34.48	567	56.9
562	15.95	565	39.03	568	55.8
Average Lot I.	# 15.75	Average Lot II.	34.42	Average Lot III.	61.07

Note # Average of two cows, as No. 561 did not finish the experiment.

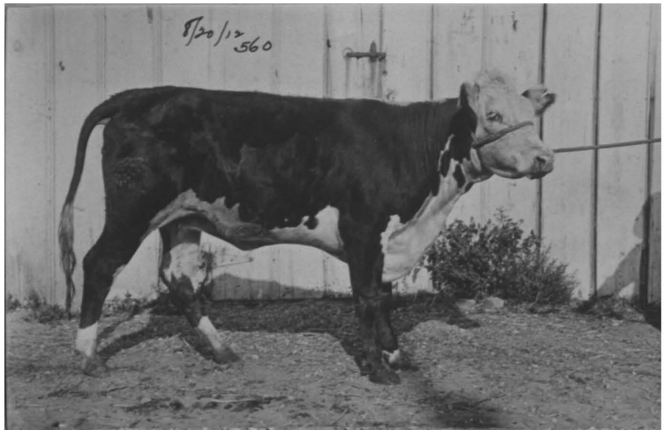
on which they are grown. While possibly explaining the differences in many cases, this explanation can scarcely apply in this instance.

CONDITION OF THE COWS DURING THE EXPERIMENT.

The condition of the cows during the experiment is best illustrated by the set of individual pictures following this page. The first set of pictures, taken August 20th, 1912, show practically no difference in either type or condition between the heifers. They were all in what might be termed medium range condition. The next set of pictures, taken December 19th, 1912, show the heifers in Lot I. to be considerably fatter than when they entered the experiment; while any change in the condition in those of Lot II. is scarcely noticeable from the pictures, but Lot III. has become thin in flesh. The next three sets of pictures taken on December 23d, 25th, and 29th, in 1913, 1914, and 1915, respectively, show the cows in Lot I. to be in what might be called good to choice condition, the cows in Lot II. in medium thin condition; while those in Lot III. were in very thin condition.

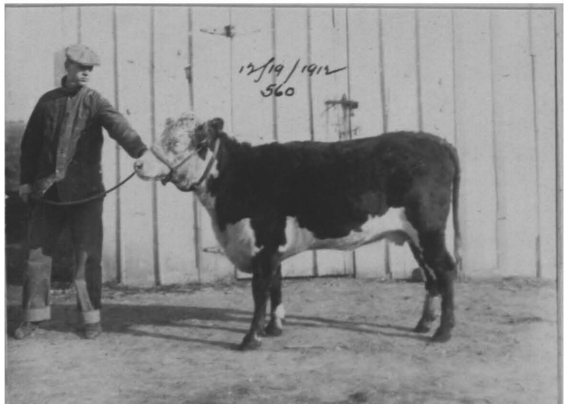
Aug. 12, 1912.

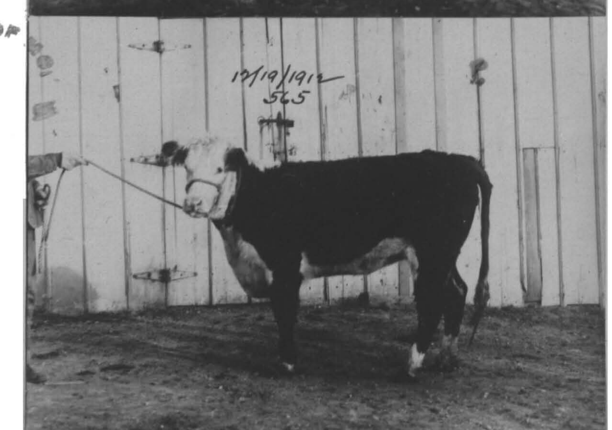
Plate II.



Dec. 19, 1912.

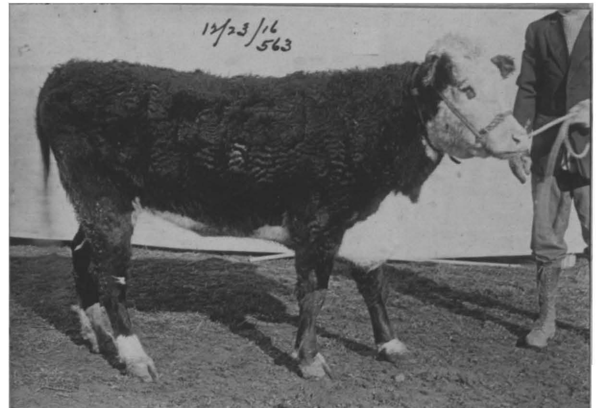
Plate III.

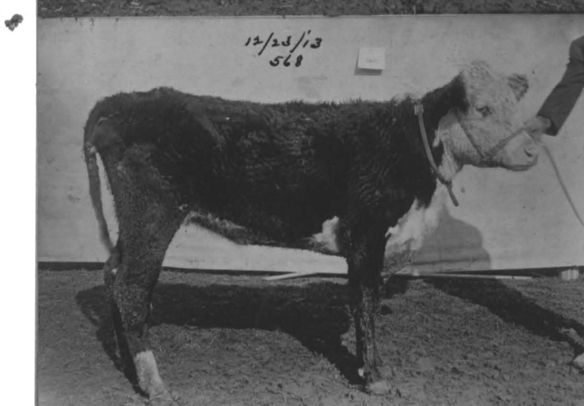




Dec. 23, 1913.

Plate IV.





Dec. 25, 1914

Plate V.

Dec. 29, 1915.

Plate VI.

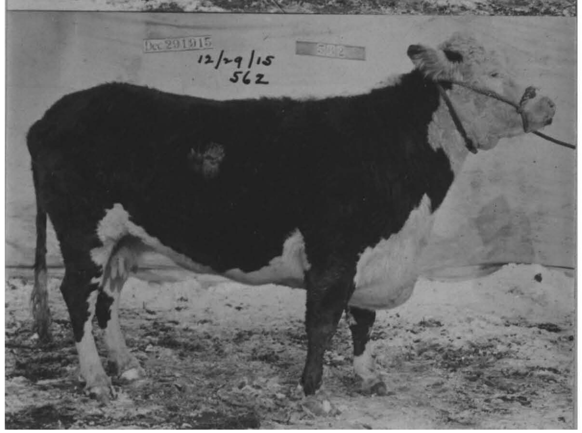


TABLE XXI.

AVERAGE WEIGHT DURING EACH THIRTY DAY PERIOD OF THE EXPERIMENT.

Period Ending	Cow 560	Cow 561	Cow 562	Avg. Lot 1	Cow 563	Cow 564	Cow 565	Avg. Lot 2	Cow 566	Cow 567	Cow 568	Avg. Lot 3.
1912												
Sep.19	707.6	667.7	655.5	674.7	578.8	742.7	634.2	651.9	702.7	576.1	644.7	641.2
Oct.19	798.4	744.1	720.2	754.2	631.4	778.9	683.5	697.9	711.7	567.1	655.3	644.7
Nov.18	817.9	820.2	779.7	805.9	673.3	803.2	695.1	723.9	685.8	554.6	654.3	631.6
Dec.18	765.4	883.2	822.5	823.7	712.2	843.3	728.4	761.3	675.6	557.2	649.9	627.6
1913												
Jan.17	799.4	949.2	860.0	869.5	758.4	883.0	753.1	798.2	708.8	587.2	662.8	652.9
Feb.16	850.6	1009.4	903.1	921.0	797.6	917.3	774.5	829.8	733.3	593.9	675.8	667.7
Mar.18	916.0	1074.8	949.7	980.2	821.8	938.8	720.9	827.2	756.9	604.7	697.9	686.5
Apr.17	936.3	1129.9	988.4	1018.2	844.6	961.6	696.4	834.2	780.0	622.5	710.9	704.5
May 17	1015.6	1213.7	1028.6	1085.9	880.8	1012.2	726.8	873.3	808.8	650.5	730.2	729.8
Jun.16	1091.1	1288.2	1077.6	1152.3	901.4	1061.6	755.9	906.3	840.8	685.0	764.2	763.4
Jul.16	1141.3	1328.5	1108.2	1192.7	887.7	1062.1	781.0	910.2	830.9	693.4	772.8	765.7
Aug.15	1173.6	1357.6	1124.0	1218.4	879.6	1034.7	787.9	900.7	797.6	677.0	756.7	743.8
Sep.14	1207.6	1384.4	1153.2	1248.4	873.4	1020.6	803.4	899.1	784.7	672.0	737.3	731.3
Oct.14	1062.7	1419.8	1177.2	1120 #	878.3	968.1	821.6	889.3	774.4	663.2	717.6	718.4
Nov.13	967.0	Died	1220.2	1093.6	880.3	803.4	837.6	840.4	711.3	671.8	715.7	699.6
Dec.13	960.5		1262.7	1111.6	910.4	793.0	862.1	855.2	683.2	591.9	667.7	647.3
1914												
Jan.12	988.5		1296.5	1142.5	932.9	803.6	893.6	876.7	731.1	619.3	661.2	670.5
Feb.11	1021.2		1331.7	1176.5	960.4	823.0	919.4	900.9	774.5	650.2	707.0	710.6
Mar.13	1029.3		1356.4	1192.9	973.8	839.7	939.3	907.6	797.7	664.5	751.5	737.9
Apr.12	1049.8		1259.4	1154.6	997.9	866.2	976.4	946.7	835.1	703.5	783.6	774.1
May 12	1064.1		1148.9	1106.5	1015.4	879.8	997.8	964.3	846.3	713.2	812.2	790.6
Jun.12	1104.9		1139.7	1122.3	1037.1	920.2	956.2	971.2	840.7	697.0	837.7	791.8

Average of two cows.

TABLE XXI. (Cont.)

AVERAGE WEIGHT DURING EACH THIRTY DAY PERIOD OF THE EXPERIMENT.

Period Ending	Cow 560	Cow 561	Cow 562	Avg. Lot 1	Cow 563	Cow 564	Cow 565	Avg. Lot 2	Cow 566	Cow 567	Cow 568	Avg. Lot 3
1914												
Jul. 11	1134.2		1141.5	1137.9	1059.1	919.6	875.8	951.5	848.7	697.6	831.9	792.7
Aug. 10	1160.4		1135.7	1148.1	1074.8	967.9	884.1	975.6	846.3	700.3	835.6	794.1
Sep. 9	1181.9		1137.4	1159.7	1088.2	977.8	882.9	982.9	838.6	700.2	832.4	790.4
Oct. 9	1200.8		1128.1	1164.5	1104.9	987.8	876.6	989.8	843.0	704.2	833.1	793.4
Nov. 8	1148.1		1117.4	1132.8	1131.0	1001.6	882.2	1004.9	853.4	717.5	848.4	806.4
Dec. 8	1057.1		1168.1	1112.6	984.5	1019.9	898.5	967.6	863.6	733.1	863.4	820.0
1915												
Jan. 7	1042.6		1212.1	1127.4	969.5	869.2	904.0	914.2	859.4	737.9	733.6	776.9
Feb. 6	1048.6		1254.6	1151.6	974.1	852.8	932.5	919.8	868.4	758.0	738.9	788.4
Mar. 8	1063.2		1311.0	1187.1	995.1	897.4	970.6	954.4	874.6	784.4	763.1	807.4
Apr. 7	1081.9		1358.7	1220.3	1004.8	917.3	1009.4	977.2	884.3	802.9	778.6	821.9
May 7	1087.7		1378.7	1233.2	1002.3	922.1	1028.4	984.3	882.9	809.6	796.1	829.5
Jun. 6	1098.3		1312.3	1205.3	996.1	897.8	1060.7	984.9	877.8	816.3	794.5	829.6
Jul. 6	1096.4		1194.4	1145.4	980.8	886.8	998.0	957.9	851.5	793.8	786.3	810.4
Aug. 5	1116.4		1163.7	1140.1	977.6	884.3	923.1	928.3	841.1	718.1	776.3	778.5
Sep. 4	1144.1		1172.9	1158.5	991.5	913.0	911.4	938.6	836.3	710.1	757.2	767.9
Oct. 4	1186.2		1205.4	1195.8	994.3	938.2	912.5	948.3	845.0	735.6	754.4	778.3
Nov. 3	1223.4		1237.4	1230.4	982.3	942.7	904.9	943.3	832.7	760.0	744.8	779.2
Dec. 3	1268.5		1265.0	1266.8	985.4	966.3	904.6	952.1	836.6	781.9	737.0	785.2
1916												
Jan. 2	1314.9		1308.2	1311.6	991.7	995.4	906.3	964.5	864.1	820.1	749.8	811.3

TABLE XXII.

Gain in Weight.

(In Pounds)

Cow No.	Initial Weight	Final Weight	Gain
560	672.33	1337.8	654.47
562	625.33	1338.4	712.07
Average for Lot I.	648.83	1339.1	680.27
563	549.67	1006.0	456.33
564	712.67	1008.4	295.73
565	625.0	910.4	285.40
Average for Lot II.	629.11	974.9	345.79
566	690.67	876.8	186.13
567	570.0	825.0	255.0
568	624.67	760.2	135.53
Average for Lot III.	628.45	820.7	192.25

TABLE XXIII.

HEIGHT AT WITHERS.

(Measurements in Centimeters.)

Date	Cow 560	Cow 561	Cow 562	Avg. Lot 1	Cow 563	Cow 564	Cow 565	Avg. Lot 2	Cow 566	Cow 567	Cow 568	Avg. Lot 3.
1912												
Aug.16	109.6	112.4	117.0	113.0	112.0	112.8	111.5	112.1	111.5	108.7	113.4	111.2
Sep.22	112.7	114.0	119.2	115.3	113.2	115.7	113.8	114.2	115.2	108.0	113.5	112.2
Oct.20	113.7	115.0	119.5	116.7	114.0	118.2	114.0	115.4	116.0	109.2	115.7	113.6
Dec.21	117.0	115.0	122.6	118.2	114.0	119.0	115.5	116.2	118.7	110.5	115.7	115.0
1913												
Feb. 8	117.5	118.5	122.6	119.5	116.2	119.0	115.7	117.0	119.0	110.5	115.8	115.1
Mar.23	119.2	121.8	123.0	121.3	119.5	120.7	116.0	118.7	120.0	111.5	116.5	116.0
May 9	120.3	124.0	124.8	123.0	119.7	122.5	117.7	119.9	120.7	113.0	118.5	117.4
Jun.26	122.3	126.0	125.5	124.6	119.7	122.5	118.5	120.2	120.5	114.6	119.0	118.0
Aug. 10	122.4	125.5	126.5	124.8	121.0	123.5	118.5	121.0	122.0	113.3	119.0	118.1
Sep.24	122.3	125.7	128.0	125.3	123.5	124.4	118.5	122.1	122.0	113.5	119.0	118.2
Nov. 8	122.0	Died	128.0	125.0	123.0	124.5	120.2	122.6	122.0	114.0	119.4	118.5
Dec.13	122.0		127.4	124.7	123.5	123.5	121.0	122.7	123.0	113.4	117.9	118.1
1914												
Feb. 6	122.3		129.0	125.7	123.5	123.2	120.5	122.4	122.0	113.0	119.0	118.0
Mar.23	123.0		128.6	125.8	126.0	124.0	121.4	123.8	124.5	114.0	120.4	119.6
May 7	124.0		130.0	127.0	126.5	124.3	123.2	123.7	125.7	115.0	120.4	120.4
Jun.22	122.7		129.0	125.9	125.0	123.4	122.6	123.7	123.7	113.7	119.8	119.1
Aug. 6	120.9		128.5	124.7	125.7	124.3	121.0	123.7	122.5	114.0	120.0	118.8
Sep.20	122.0		127.0	124.5	124.7	124.8	121.0	123.5	123.8	114.0	119.2	119.0
Nov. 7	121.8		127.0	124.4	127.0	122.5	121.5	123.7	122.6	113.5	120.5	118.9
Dec.25	121.5		128.0	124.8	126.0	122.0	121.5	123.2	124.5	113.5	120.0	119.3

TABLE XXIII. (Cont.)

HEIGHT AT WITHERS.

(Measurements in Centimeters.)

Date	Cow 560	Cow 561	Cow 562	Avg. Lot 1	Cow 563	Cow 564	Cow 565	Avg. Lot 2	Cow 566	Cow 567	Cow 568	Avg. Lot 3.
1915												
Feb. 7	123.0		128.5	125.8	126.0	123.5	122.0	123.8	125.0	114.5	120.0	119.8
Mar. 27	123.5		130.0	126.8	127.0	125.0	122.0	124.7	126.5	116.0	121.0	121.2
May 15	122.3		128.0	125.8	127.5	125.0	122.5	125.0	126.5	116.5	121.0	121.3
Jun. 25	122.8		129.5	126.2	124.5	124.5	121.8	123.6	127.0	117.0	121.5	121.8
Aug. 10	123.1		130.0	126.6	127.0	125.0	122.0	124.7	126.5	116.5	121.0	121.3
Oct. 2	123.0		129.3	126.2	127.8	125.3	121.5	124.9	126.8	116.0	120.6	121.1
Nov. 13	123.5		128.7	126.1	126.5	125.1	122.5	124.7	127.0	116.5	121.4	121.6
1916												
Jan. 1	124.0		129.5	126.8	127.5	124.5	124.4	125.5	126.5	116.0	121.0	121.2

TABLE XXIV.

Increase in Height at Withers.

Cow No.	Initial Measurement cm.	Final Measurement cm.	Increase cm.
560	109.6	124.0	14.4
562	117.0	129.5	12.5
Average for Lot I.	113.3	126.75	13.45
563	112.0	127.5	15.5
564	112.8	124.5	11.7
565	111.5	122.4	10.9
Average for Lot II.	112.1	124.8	12.7
566	111.5	126.5	15.0
567	108.7	116.0	7.3
568	113.4	121.0	7.6
Average for Lot III.	111.2	121.17	9.97

GROWTH.

Table XXI. contains the average weight of each cow and the average for the separate lots for each thirty-day period. Table XXII. contains the initial and final weights and the gains of each cow and lot. The results are as expected. Lot I. averaged 680.3 lbs. ; Lot II. 345.8 lbs.; while Lot III. averaged only 192.3 lbs. gain; the gain in weight varying directly with the plane of nutrition.

Burlingham and Gillette[1], studying the growth of dairy heifers, conclude that the increase in height at withers is a very good measure of skeletal growth, and that a proper standard for measuring growth of cattle includes both the gain in weight and the increase in height at the withers.

Table XXIII. contains the "height at withers" measurements of the cows and the average of each lot. Table XXIV. includes the increase in height in each case. The rapidity of the increase in height varied directly with the plane of nutrition, the cows receiving the more feed growing faster. In total increase in height the results were the same, the average increase being, Lot I. 13.45 cm.; Lot II. 12.7 cm.; and Lot III. 9.97 cm. The difference

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1.
Masters Thesis, M.U. 1914.

in the increase in height was not so marked as was the difference in the gain in weight. The measurements will be continued after the experiment proper is completed, to determine if the cows have completed their growth. Previous investigators[1] have noted that in cattle nutrition affects the growth in height at withers.

PARTURITION.

There were no abortions during the experiment.

Cow No. 561 suffered an eversion of the uterus at her first parturition, and died the next day. Cow No. 560, 238 days pregnant, on February 5th, 1916, suffered a prolapse of the vagina, and although she received constant veterinary attention, she died on February 18th, 1916, without delivering a calf. Post mortem examination showed the calf to be in normal position. Williams[2] says that highly fed, stabled dairy cows are more predisposed to the above troubles than cows which receive plenty of exercise. Dr. Backus of the Veterinary Science Department did not attribute the trouble in these instances to the condition or the feed of the cows, and said that it was probably just a coincidence that both cases happened to be in the same

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1. Eckles. Mo. Bulletin No. 135.
   Waters. (Proc. Soc. for the Promotion of Ag. Science. (1908)

2. Veterinary Obstetrics, 1909, pp 849 & 828.

lot. The number of births were so few that the data did not afford a basis for a conclusion that the condition of the cow either does or does not increase the labor at parturition.

OESTRUM.

Table XXV. gives the number of days elapsing after each parturition until the first period of oestrum following. There were five of such periods in each lot, the averages being, Lot I. 63.2 days; Lot II. 100.4 days; and Lot III. 152 days. The shortest interval in Lot I. was 18 days, and the longest was 122 days; the shortest in Lot II. was 64 days and the longest 148 days; and in Lot III. the shortest was 55 days; while the longest was 318 days. Note that the shortest interval of all the lots was in Lot I. and was 18 days; while the longest was 318 days and was in Lot III. The results indicate that a high plane of nutrition tends to shorten the interval between the date of parturition and the occurrence of the first "heat" period following.

Owing to the fact that a bull was not available in a few instances when cows came in "heat", and that some of the cows had to be rebred, there were several intervals between successive heat periods, and these are included in Table XXVI. There were twenty such intervals in Lot I.,

TABLE XXV.

Number of Days Elapsing From Parturition to First Period of Oestrum.

Cow No.	First Parturition	Second Parturition	Third Parturition	Average
560	18	118	35	
562	122	23		
Average Lot I.				63.2
563	64			
564	148	83		
565	105	102		
Average Lot II.				100.4
566	318			
567	214	55		
568	105	68		
Average Lot III.				152

TABLE XXVI

Length of the Intervals Between Successive Oestrum Periods.

(In Days)

Period	No. 560	No. 561	No. 562	Lot I.	No. 563	No. 564	No. 565	Lot II.	No. 566	No. 567	No. 568	Lot III.
		23	24		47	22	25		30			
		19	22		63	22	19					
		18	21				246					
		18	21									
			22									
			83									
			22									
			19									
1st			25									
					188				214	52		
					153					20		
										20		
										19		
2nd												
						136					22	
											20	
											62	
3rd												
	42											
	41											
	46											
	21											
4th												
Average				29.8				89.4				51

with an average of 29.85 days; ten in Lot II., with an average of 89.4 days; and nine in Lot III., with an average of 51 days. The longest interval in the entire experiment was in Lot II., being 246 days; while the shortest was in Lot I., there being two intervals of 18 days in length. The usual interval elapsing before the reoccurrence of oestrum in the cow is 21 days, but a variation of a few days either way cannot be considered an irregularity of any importance. Calculating the number of intervals exceeding 25 days in length, we find that of the twenty intervals in Lot. I., four exceed this length; of the ten intervals in Lot II., six exceed it; and of the nine intervals in Lot III., four exceed it. The longest interval in Lot I. was 83 days, which was exceeded by four intervals in Lot II. and by one interval in Lot III.; although there were twice as many intervals in Lot I. as in either Lots II. or III.

None of the cows became barren during the experiment, and therefore the data does not include any records of the oestrum periods of overfat barren cows.

Although it is hardly possible to explain the differences between lots II. and III., it is easily seen that the oestrum periods in these did not reoccur with the same regularity as in Lot I. The results indicate that a plentiful food supply is favorable for the regular and consequently the frequent reoccurrence of oestrum in cows.

CONCEPTION.

Table XXVII. gives the number of services required for each pregnancy. Cows Nos. 562, 563, 564, 565, and 567 have been bred and appear to be safe with calf at this time (April 25th, 1916); therefore these pregnancies are considered in this table.

Lot I. averaged two services; Lot II. 1.5 services; while Lot III. averaged 1.75 services for each pregnancy; that is, in Lot I. 50%, in Lot II. 66%, and in Lot III. 57.1% of the services resulted in conceptions. In Lot II. there were eight conceptions and four cows conceived at the first service, but no cow was rebred more than once. In Lot I. there were seven conceptions and two cows were rebred twice, and one cow was rebred three times. In Lot III. there were eight pregnancies, five of which resulted from the first service; one cow was rebred once, another twice, and a third was rebred three times. Approximately one-half of the cows in each lot conceived at the first service. The differences could very easily be due to the small numbers from which the averages have been calculated.

None of the cows became barren during the experiment, but this fact, on account of the small number of animals used, cannot be considered proof that a high condition of flesh is not conducive to barrenness.

TABLE XXVII.

Number of Services Required for Conception.

Cow No.	First Conception	Second Conception	Third Conception	Fourth Conception	Average
560	#	1	1	4	
561	1				
562	3	1	3		
Average Lot I.					2
563	2	2			
564	1	1	2		
565	2	1	1		
Average Lot II.					1.5
566	1	2			
567	1	4	1		
568	1	1	3		
Average Lot III.					1.75

Note # Cow served before experiment began.

The data obtained in this experiment is too limited to afford any conclusions on the relation of the plane of nutrition to conc eption or barrenness.

GESTATION.

Table XXVIII. gives the length of each gestation period. The average of the five periods in Lot I. was 283.6 days; of five periods in Lot II. was 286 days; and of the seven periods in Lot III. 291.6 days. The shortest separate period was in Lot III., namely the second period of cow No. 568. It appears that this period was terminated by a premature birth, as the calf weighed only 39 lbs., was very weak, and evidently would not have survived, and its chemical analysis as will be shown later indicated that it had not reached the same state of maturity as the other calves. If we eliminate this period from the table, the average of Lot III. is 294.2 days, being between nine and ten days longer than the average of Lots I. and II. These averages indicate that the length of the period may be influenced by the plane of nutrition. Upon analyzing the separate periods this becomes even more apparent.

The difference between Lot I. and Lot II. is not marked, the shortest period in both lots being 280 days; the longest period in Lot I. was 289 days, there being one period of the same length in Lot II., and also one which was

TABLE XXVIII.

Length of Gestation Periods.

(Days)

Cow No.	First Period	Second Period	Third Period	Average
560	#	281	286	
561	289			
562	282	280		
Average Lot I.				283.6
563	289			
564	293	285		
565	283	280		
Average Lot II.				286.0
566	285	296		
567	299	284		
568	303	276	298	
Average Lot III.				291.6

Note # Cow pregnant when experiment began.

longer, viz. 293 days. Of a total of seven gestation periods in Lot III., four exceeded 290 days in length, ranging from 296 to 303 days, and if the second gestation period of cow No. 568 (as stated above the evidence indicates that this period was terminated by a premature birth) is excepted from the records, there were only two periods of less than 290 days in length. Of a total of ten periods in lots I. and II. combined there was only one separate period exceeding 290 days in length; namely, the first period of cow No. 565, which was 293 days long.

The total number of periods is small, but the results are so marked that it appears that an extremely low plane of nutrition tends to lengthen the gestation period.

BIRTH WEIGHTS.

Table XXIX. contains the birth weights of the calves. The five calves in Lot I. averaged 86.7 lbs.; five calves in Lot II. 81.2 lbs.; and the seven calves in Lot III. 67.1 lbs. If we eliminate the smallest calf, 568B, from the calculation, the average of Lot III. will be 71.8 lbs.; still 9.4 lbs. below the average of Lot II. and 14.9 lbs. below the average of Lot I. There was not one calf in either lots I. or II. with a birth weight as low as the average of Lot III. when calf No. 568B is included in the

TABLE XXIX.

Birth Weight of Calves.

(In Pounds)

Cow No.	Calf A	Calf B	Calf C	Average
560	#	94	88	
561	81			
562	89	86		
Average Lot I.				87.6
563	87			
564	83	70		
565	91	75		
Average Lot II.				81.2
566	72.5	91		
567	69.5	64		
568	59	39	75	
Average Lot III.				67.1

Note # This calf not considered in this experiment.

calculation, and none in Lot I. and only one in Lot II., when calf No. 568B is omitted from the calculations.

There was only one calf, No. 566B, in Lot III. with a birth weight as high as the smallest calf in Lot I., but three calves in Lot III. were heavier than the smallest calf in Lot II.; while a fourth was only .5 lb. lighter. All of the five calves in Lot I., three of the five calves in Lot II., but only one of the seven calves in Lot III. exceeded 80 lbs. at birth. This calf No. 566B weighed 91 lbs., and was one of the three heaviest of the entire seventeen calves. It seems that the birth weight of this calf was not decreased by the restricted ration of the dam, but it is impossible to determine what it would have weighed had the cow been supplied with more nutrients. Certainly with any very great increase in size it would have been an abnormally large calf.

Contrary to the general opinion, these figures indicate that if the conditions are extreme enough, the birth weight of the calves may be influenced to some extent at least by restricting the rations of the dams. The difference between Lots I. and II. alone is not great, and with the limited number of calves, hardly affords a basis for a conclusion that the birth weight of the calf can be influenced by the feeding of the cow. Thus it is possible that conclusions that the birth weight of the calves cannot be affected by the feed of the dam have been based upon

observations of cows which have not been subjected to the extreme conditions under which Lot III. was handled. It appears that any differences in the amount of the ration which is not greater than is usually found will have no appreciable effect upon the birth weight of the calf. The length of time during which a cow is on an extremely low plane of nutrition may be a factor. In the range districts of the United States cows are often reduced to as thin or a thinner condition than the cows in Lot III., and it is the opinion of ranch men that the condition of the cow makes no material difference in the size of the calf. The writer has not been able to find any experimental or statistical data on the subject under these conditions. The extremely low condition to which the range cows are reduced lasts only a few weeks, and therefore they scarcely compare with the cows in Lot III., which were continually maintained in the same extremely thin condition for a period of several months.

Excepting calf No. 568B, which as mentioned before was very weak at birth, and apparently would not have survived, there appeared to be no difference in the strength of the calves of the different lots.

CHEMICAL COMPOSITION.

Table XXX. contains the percents of fat, moisture, nitrogen, and ash of the eight calves analyzed.

The greatest difference in the analysis is found in the moisture column, the two calves in Lot I. averaging 72.2%; the four calves in Lot II. averaging 72.6%; while the two calves in Lot III. average 74.3%. Upon closer inspection it can be seen that the high average moisture content of Lot III. is due to calf No. 568B, which analyzed 75.8% moisture. As indicated in previous paragraphs, this calf evidently had not reached as full a degree of maturity at birth as the other calves of the experiment. The other calf in Lot III., 567B, analyzed a higher moisture content than the average of either Lots I. or II., but was exceeded by the individual analysis of two calves in Lot II., viz. No. 565A and 563A. It is a significant fact that excepting calf No. 568B, the calves analyzing both the highest (No. 565A, 73.3%), and the lowest (No. 565B, 71.8%) percent of moisture are to be found in the same lot. Note that both of these calves are from the same dam. Thus, the high average moisture content of Lot III. is more probably due to the immaturity of calf No. 568B at birth than to any difference in the rations of the dams.

In fat content Lot I. averaged 3.9%; Lot II. 3.6% and Lot III. 3.4%. These differences, while very small,

TABLE XXX.

Chemical Analysis of the Calves.

(In Percents)

Calf No.	Water	Fat	Nitrogen	Ash
560B	72.3	3.8	--	4.3
562B	72.1	4.0	3.1	4.3
Average Lot I.	72.2	3.9	3.1	4.3
563A	72.9	4.0	2.9	4.3
564B	72.3	3.3	3.1	4.6
565A	73.3	3.2	2.8	4.6
565B	71.8	3.9	3.0	4.6
Average Lot II.	72.6	3.6	3.0	4.5
567B	72.8	3.2	2.9	5.0
568B	75.8	3.5	2.5	4.0
Average Lot III.	74.3	3.4	2.7	4.5

might be taken to indicate that there was a tendency for the percent of fat in the calf to vary slightly with the plane of nutrition of the dam; but upon inspecting the analyses of the individual calves it is found that the lot (Lot II.) containing the largest number of analyses also contains analyses at both the high and the low extremes.

Again excepting calf No. 568B, which analyzed the lowest percent, viz. 2.5%, the variation in the nitrogen content of the individual calves was very small, being only .3%, and analyses on both extremes are again found in Lot II., which contains the largest number of individual analyses. The nitrogen analysis of calf No. 560B was not available. Table XXX. evidently contains no basis for a conclusion that the plane of nutrition of the dam will affect the nitrogen content of the calf.

Calf No. 567A analyzed the highest (5%) ash content; while the other calf in the same lot had the lowest (4%) ash content. Both of the calves in Lot I. analyzed 4.3% ash, which was also the analysis of calf No. 563A in Lot II., the other three calves in Lot II. analyzing 4.6%.

The conditions have been so extreme, the variations in the analysis so small, and the number of analyses so few, that it cannot be said that the figures afford a basis for a conclusion that the plane of nutrition of the dam affects the percent of total moisture, fat, nitrogen, or ash of the calf at birth. This question deserves a more extensive and detailed investigation.

SUMMARY.

The small number of animals used in this experiment does not afford a basis for final conclusions on at least some of the questions considered. Until more data is available, the following conclusions appear to be tenable:

1. A high plane of nutrition is favorable for maximum rate of skeletal growth in cattle, as measured by height of withers.

2. Cattle on a low plane of nutrition have a greater appetite for salt than cattle on a higher plane of nutrition.

3. Nutrition exerts a direct influence upon the period of oestrum in cows; a plentiful food supply is favorable for the reoccurrence of oestrum after parturition, and the regularity and frequency of the periods.

4. An extremely low plane of nutrition has a tendency to lengthen the gestation period of cows.

5. Variations in the ration of the cow, within ordinary limits, do not affect the birth weight of the calf, but the birth weight of the calf is reduced, in some instances at least, when the cow is on an extremely low plane of nutrition for a long period of time.

6. The plane of nutrition of the cow does not affect the percentage of total moisture, fat, nitrogen, or ash of the calf at birth.

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DEPARTMENT OF DAIRY HUSBANDRY

May 18, 1916.

Dean Walter Miller,
Academic Hall.

Dear Dean Miller:-

I have gone over the thesis by. Mr. DeH Branson, recently referred to me and will say that as far as subject matter is concerned I think it meets the general standard which has been established for the Masters dissertation.

In going over this thesis I did not consider it was my duty primarily to give attention to the language employed or grammatical errors. I will say, however, from this standpoint the thesis is decidedly deficient. In fact, two or three paragraphs are so ambiguous that it is somewhat questionable as to their meaning and I am not sure but what we would be justified in asking that some parts, especially pages 32 and 35, be rewritten. The tendency of the author is to use too many long and involved sentences and to give too little attention to the proper choice of words. I note also that the references given are not in standard form and furthermore they lack uniformity in regard to the arrangement used.

Yours very truly,

C. H. Eckles

Professor Dairy Husbandry.

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