TO STUDY THE EFFECT OF PREGNANCY AND OF NURSING
ON THE MAINTENANCE REQUIREMENT OF MARES

by

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INTRODUCTION.

A clear understanding of the main principles underlying the nutrition of farm animals has never been more important to the stock farmer than at the present time, with prevailing high prices for feed and labor. In order to secure profitable returns, the farmer must be able to adapt these principles to the special conditions that surround him.

It is quite generally conceded that the investigations of the experiment stations, as well as the instruction in the schools and colleges to determine a few of the large number of principles of nutrition, have been more exhaustive in their application to cattle, hogs, sheep, and poultry than to horses. The aimless, hit or miss, haphazard system prevails in the production of horses more than in any other class of livestock; the scrub stallion is less in disrepute than the scrub bull, and most producers of market cattle, hogs or sheep devote themselves more intelligently to their

enterprise than do the breeders of horses.

A review of literature shows that little has been done experimentally on determining the effect of pregnancy and of nursing on the maintenance requirements of mares.

The basis of this thesis is a study of the requirements of two mares under the conditions of pregnancy and nursing. The data secured from the feeding test and a digestion trial for each part of the experiment is compared and a summary of the results presented.

THE ENERGY VALUES OF FEEDING STUFFS AND THE ENERGY REQUIREMENTS OF THE ANIMAL BODY.

From the study of physics we learn that energy stored up is called 'potential energy'; if this energy is transformed into motion it is called 'kinetic energy'. From chemistry we find that the sun is the source of all energy. Plants by means of the chlorophyll which they contain are able to store up kinetic energy of the sun in potential form as proteins, starches, fats, etc. The animal, however, is unable to do this and is dependent for its supply upon the potential energy of the vegetable kingdom. The food may then be called the sole source of energy to the animal body. The animal may be looked upon as a mechanism for transforming the stored up or potential energy of feeding stuffs, or of its own body tissues into active or kinetic forms of heat or motion.

Armsby calls the total amount of energy stored in a feed the 'heat of combustion' of the feed. It is usually expressed in calories or therms per one hundred pounds. A calorie is the amount of heat required to raise the temperature of one kilogram one degree Centigrade or one pound of water four degrees Fahrenheit.

It seems that not all the energy contained in a feed is accessible to the animal body. That a part of the energy passes from the body as potential energy of the undigested food material and is found in the feces. Another part is

is lost through fermentations occurring in the digestion tract. Some of this energy is liberated as heat of fermentation which may not be entirely wasted, especially in cold weather when it may help to maintain the temperature of the body.

"There may still be a final portion of this energy which passes out as potential energy of methane or hydrogen gas formed during the fermentation of the carbohydrates and the putrefaction of the protein material, and is lost to the animal body. Again it is thought that there are also certain partially oxidized nutrients, capable of further oxidation, that pass out in the urine"¹. Thus the energy which can be liberated and utilized in the animal body, Armsby calls the 'metabolizable energy' or 'the available energy' of the feed.

He also speaks of it as the 'fuel value'. Briefly, the metabolizable or available energy of the feed may be regarded as the gross energy of the feed less the potential energy of the feces, the urine, and the intestinal gases"². To determine the gross energy it is necessary to use a bomb calorimeter, while for the metabolizable energy it requires the bomb and the respiration calorimeters. Although this method of determination is not considered the best, up to the present, however, but a comparatively small number of experiments upon domestic animals are on record in which the metabolizable energy of the food has been actually determined.³

Armsby, from the results of his own experiments and

1. Hart: Lectures in Agricultural Chemistry.
2. Illinois Station: Bulletin No. 163.
3. Armsby: Principles of Animal Nutrition. Page 332.

those of Kellner and Kuhn, gives the following values for the metabolizable energy of the digestible nutrients of the feeding stuffs of cattle:

Nutrient.	Metabolizable energy per gram.	
	Calories.	
Protein (wheat gluten)	4.9	
Protein (molasses)	4.0	
Protein (timothy hay)	3.1	
Protein (meadow hay)	1.6	
Fat (peanut oil)	8.8	
Fat (hay)	8.3	
Starch	3.7	
Crude Fiber	3.4	

For Horses and Swine.

	Horses.	Swine.
Protein (mixed grain)		4.1
Protein (mixed ration of oats		
hay, and straw)	3.2	
Carbohydrates (n. f. extract)	4.2	
Carbohydrates (mixed ration)	3.5	

The most striking thing about these figures is the wide range of results upon the same class of nutrients. Such meager data as scientists now possess regarding other animals than cattle indicate that the results vary with the species of animal. Armsby concludes by saying: "That at present our knowledge is too imperfect to allow of the assignment of average values for the metabolizable energy of the different nutrients, even for a single species of animal".

"The metabolizable energy serves two purposes. First, it supplies the energy for carrying on the various activities of the body. Second, if the supply is in excess of the body requirements, a portion may temporarily escape conversion into the kinetic form and be stored up as gain of tissue, notably of fat. Briefly, the metabolizable energy of the food is used for the production of 'physiological work', and, if there be any excess, for the storage of energy".¹

Physiological Work--is the sum of all the activities of the body. Armsby has divided physiological work into (1) Internal work--that is, the work of circulation, respiration, secretion, etc; (2) The production of heat to maintain the body temperature; (3) Work of digestion and assimilation; and the (4) Work of the voluntary muscles.

Internal Work--The internal work of the fasting organism may be roughly classified as muscular, glandular and cellular. It seems that the energy expended in all forms of internal work ultimately takes the form of heat. According to Armsby, then, the total heat production of a fasting, quiescent animal may be used as a measure of the total amount of energy expended in the performance of internal work. Using the total heat production as a measure, it has been found that the fasting, quiescent animal adjusts its metabolism to the minimum and it then remains quite constant. This minimum represents the aggregate demands of the vital activities, that is, of the internal work.

1. Armsby: Principles of Animal Nutrition. Page 336.

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1. Armsby: Principles of Animal Nutrition. Page 336.

Muscular Work-- of the quiescent animal consists principally of the work of the circulatory and respiratory systems and that necessary to maintain muscular tonus. It is surprising how the metabolism may be increased by apparently insignificant exertion. An animal even standing up or switching flies may materially increase the metabolism.

¹
Zuntz and Hagemann found that a few flies in the respiration chamber with a horse increases the metabolism 10 per cent. It is quite noticeable at stock shows and fairs that the owners of live stock have realized this fact, since they prefer their fat stock to lie down rather than stand up too much. Armsby in determining the difference of these two activities has found that standing increases the metabolism of a steer 30 per cent. Another interesting example is a comparison of the country boy who has been raised on the farm and accustomed to work, and the city boy who has never worked on the farm. The country boy stands the work, as a rule, much easier, because he has become accustomed to it; for according to experiments on a man working a treadmill the metabolism after twenty-two days' practice decreased 10 per cent, the work remaining the same. And after fifty-six days' practice ² decreased 25 per cent. Small amounts of energy are also expended in glandular work, such as the activities of the various secretory, absorptive, and excretory organs; also in cellular activity there is energy expended in the filtration, osmosis, protoplasmic motion, mitosis, and imbibition.

1. Armsby: Principles of Animal Nutrition.
2. Kellner: The Scientific Feeding of Animals.

The Production of Heat to Maintain the Body

Temperature--An animal is subject to a considerable variation of external conditions, particularly of temperature which tends primarily, to effect the rate of heat emission, and secondarily, to modify the amount of heat produced. As regards body temperature, scientists have divided animals into two classes: poikilothermic or cold blooded animals, whose temperature is about the same as that of their surroundings: and homiothermic or warm blooded animals, whose temperature remains approximately constant under all conditions. The latter class is of greatest interest to us since man and all the domesticated animals belong to it. The following table gives the normal body temperature of the principal farm animals:

Animal	Normal Temperature.
Horse-----	99.5-101.5 degrees.
Ox-----	100-102 "
Sheep -----	102-104.5 "
Pig -----	100-103 "
Dog -----	100-101 "
Fowls -----	106.5-108.5 "

As the animal is constantly producing heat, heat must be given off at the same average rate as it is produced, if the constancy of the body temperature is to be maintained. It has been calculated that if the body of a man were unable to give off the heat which it produces, its temperature would be raised to the boiling point in a single day. As the

1. Hadley: Lectures to Students on Diseases of Farm Animals.

external conditions of temperature are subject to frequent and sudden changes, the balance of heat production and heat emission must be in such a condition that quick regulation is possible.

Heat Regulation--that is, animal adjusting itself to the thermal environment may be accomplished by one or both of two ways:

(1) By regulating the heat emission, this work is called the physical regulation.

(2) By varying the heat production, which is called the chemical regulation.

Armsby considers heat to be lost from the body in the following ways: (1) by conduction, (2) by radiation, (3) by evaporation of water, and (4) in the excreta as sensible heat.

By conduction, heat is transferred directly to anything that the animal touches, especially the air, that has lower temperature than that of the body. The rate of loss is dependent upon the conductivity and relative temperatures of the animal body itself and of the substance with which it is in contact.

By radiation there is a constant loss of heat to objects cooler than the body, not in immediate contact with it. The amount lost depends upon the temperatures and the radiating powers of the body.

By evaporation of water from the skin which we call perspiration, and from the lungs which is called

respiration, a large amount of heat may be removed as latent heat of evaporization. Of course this loss depends upon the amount of water transpired, upon the humidity of the air and its rate of movement. This is quite noticeable with farm animals on a cool day or a very windy day in comparison with a still hot day when sweat is quite visible on the body; also by the demand for water under the same condition.

The heat removed by the animal in the excreta seems to be small or insignificant as compared with the other three channels mentioned above.

¹
Lusk says: "The pathway for the loss of heat varies with the temperature of the environment. At a low temperature there is little evaporation of water and at a temperature of 37^o (Centigrade) there can be no heat loss by radiation and conduction, and water evaporation removes the whole of it. In the dog at a high temperature there is distention of the limbs to promote heat loss by radiation and conduction and rapid breathing with extension of the hyperemic tongue to promote evaporation of water. In the horse and in man especially there is an outbreak of sweat, which is not possible in the dog as its skin does not secrete sweat".

If an animal is exposed to the cold there is a contraction of the capillaries of the skin and a relaxation of those of the viscera. Hence, not so much blood goes to the surface of the body and the loss of heat through radiation

1. Lusk: The Science of Nutrition.

and conduction is decreased. Exposure to heat has the opposite effect and the loss of heat by radiation and conduction is increased.

If there is a high temperature the activities of the sweat glands are greatly stimulated and the evaporation of water from the body is promoted.

There are certain meteorological factors besides temperature which affect the metabolism. The wind by removing the layer of warm, moist air next the body and supplying a layer of cold air, increases the emission of heat by conduction and evaporation of water. Thus an animal can withstand a lower temperature in a still atmosphere than in a brisk wind.

These conditions were quite noticeable during the feeding test to secure data for this thesis. When the mares ran out at night, the following morning they weighed heavier and almost always refused to drink water. If the previous night happen to be very cool and not windy the conditions were even more noticeable; if warm nights less apparent. If the mares remained in the barn during the day and night, they always weighed less than when they exercised in the lot. On windy nights there was not such a marked difference in their weights and demand for water as compared with the conditions in the barn over night.

Thus it seems that during the time spent outdoors on cool nights there was a contraction of the capillaries, a

decrease of blood rushing to the surface, therefore a reduction of heat through radiation and conduction. On the cool windy nights there was an increase of the emission of heat by conduction and evaporation of the water, therefore a loss to a small extent in weight and a demand for water.

Chemical Regulation--" Just as there is a superior limit beyond which the regulation of the body temperature by means above described cannot be carried(i. e. the conditions of physical regulation), so it is obvious that there must be a lower limit of regulation. However much the cutaneous circulation may be reduced, the skin will always lose heat to a sufficiently cold environment faster than it is being generated by the internal work of the body. Under these circumstance the only method by which temperature of the animal can be maintained is an increase in the rate of generation of heat." ¹

This condition is the same as burning more coal in the furnace on a cold day in order to maintain the temperature of the house. This regulation of the generation of heat Armsby calls, 'chemical regulation'. The temperature at which the chemical regulation ceases is known as the 'critical temperature'. Below it the regulation is chiefly chemical, and above it, chiefly physical.

The critical temperature for farm animals has not been definitely determined. In case of cattle and probably of sheep, it seems to be rather low for animals consuming an ordinary ration. Armsby and Fries have found that at about

1. Armsby: Principles of Animal Nutrition.

^o
18 C the ration of cattle can be reduced considerably below the maintenance requirement without any evidence of increased oxidation of tissue for the sake of heat production. In the case of fattening animals consuming heavy rations and therefore producing a large amount of heat as a result of digestive work, the critical temperature would be still lower and experiments upon such animals have shown that they may be exposed to comparatively low temperatures, as in an open shed or yard, without causing them to oxidize any more food material. For the horse, the critical temperature seems to be considerable higher than for the ruminants.

Work of Digestion and Assimilation--Since the time of Lavoisier, it has been known that the consumption of food increases the metabolism and the consequent heat production. This increased metabolism is due to the work of digestion; its chief factors are prehension, mastication, deglutition, rumination, peristalsis, etc., and the work of the various secretory glands which provide the digestive juices, the work of absorption, also the digestive processes of solution, hydration, cleavage, etc., which the nutrients undergo during digestion.

In ruminants, the fermentations of carbohydrates liberate a large amount of energy in the form of heat. There is also a large fraction of the gross energy of the carbohydrates carried off in the potential form in the combustible gases produced, as well as a portion liberated as heat of production. This heat of fermentation amounts to about 12.5

per cent of the total energy of the digested carbohydrates,
as estimated by Armsby.¹

The food and water consumed by an animal have to be warmed to the temperature of the body. If the water be cold a large amount of heat may be needed for this purpose; but this warming is usually accomplished at the expense of the heat generated by muscular, glandular and fermentative actions as already mentioned.

Experimental Results--It has been found by Magnus-Levy (Armsby)² that in the case of the dogs and man from 1 to 3 per cent of the metabolizable energy of fat was expended in the work of digestion and assimilation. Carbohydrates, in the case of dogs, require 9 per cent of their metabolizable energy for the work of digestion and assimilation. Protein required 15 per cent of its metabolizable energy for the digestion work. From these results it is noticed that protein caused the greatest increase in the metabolism and fat the least, with carbohydrates intermediate.

Zuntz, Lehman, and Hagemen found that in case of the horse considerably more energy was required for the digestion of the hay than for the digestion of grain due to a large amount of crude fiber in the hay. These investigators found that approximately 4.5 per cent of the gross energy of hay was expended in its mastication. Oats required about 1 per cent and corn about 0.3 per cent of their gross energy. A ration of straw, oats, and hay required about 11

per cent of the metabolizable energy for mastication. The following comparison of different feeds, taken from the results of investigators, shows the number of calories of energy expended in the mastication of 1 kilogram of the material named:

	Calories. ¹
Hay-----	167.5
Green Alfalfa-----	30.4
Oats-----	47.0
Maize -----	13.8

Kellner found that by grinding straw he reduced the expenditure of energy for mastication by about 0.66 calories for each gram of crude fiber present in the staw.

Energy of Food-Available and Net Energy--So far in the study of energy it has been found that not all of the gross energy of a feed is utilized by the animal body, for as Henry says: "(1) A part of the food passes through the alimentary tract undigested. (2) The carbohydrates, especially the woody fiber, undergo fermentations in the intestines and paunch, gases are evolved which are without fuel value to the animal. (3) When the protein substances in the body are broken down they form urea, a nitrogenous compound which escapes through the kidneys. Urea has fuel value which is lost to the body".² Deducting these three losses from the gross energy of the feed, the part that remains is called the 'metabolizable' or 'available energy', or that portion which the animal can use for body purposes. But a portion of this total available

energy of any food must be expended in the work of masticating and digesting it and of assimilating the digestible nutrients. "The energy so expended finally takes the form of heat, but is not available for other purposes in the body, since the animal has no power to convert heat into other forms of energy".¹

That portion of the energy which remains after masticating, digesting, and assimilating the food is called the 'net energy' of the food. This energy is used by the animal in the work of heart, lungs, and other internal organs. If a surplus remains after satisfying the maintenance requirement of the animal, such surplus may be used for producing fat, growth, milk, or wool, or in the performance of external work, etc.

It seems from the study of Armsby experiments that the character of the feed has considerable influence upon the availability, for example the average availability of metabolizable energy in hay (timothy) is 56 per cent; for clover hay 59 per cent; for corn meal 69, and for wheat bran 55 per cent.

It is not possible to present the exact amounts of net energy in the various feeding stuffs, but Armsby has calculated from his own and Kellner's results the 'approximate' amounts in the different feeds. These values represent fairly well the relative values of feeding stuffs for cattle

(especially for the dairy cow) and sheep, and probably for horses, but for swine their value is quite uncertain from the experiments up to the present time.

To get a more definite idea of the uses and disposition of the energy of the feed the following table taken principally from Armsby will be of interest:

Gross Energy:

Energy of Excreta:

Energy of feces.

Energy of Urine.

Energy of Intestinal Gases.

Metabolizable Energy:

Physiological Work:

Internal Work.

Work of Heat Production.

Work of Digestion and Assimilation.

Work of Voluntary Muscles.

Storage of Energy.

Summary--From a review of literature at hand, it seems that in general about one-third of the potential energy directly consumed in muscular exertion is recorded as mechanical work. The rest takes the form of heat within the body and is lost so far as the production of work is concerned.

This does not take into consideration the energy lost in the excreta, nor that expended in digestion, assimilation, or maintenance. "Atwater has found that on the average 19.6 per cent of the gross energy of the food was recovered in the work of a man. The best steam engines have about the same efficiency, while the average engine falls below 10 per cent. Gasoline engines range in efficiency from 18 to 25 per cent. Thus as a mere machine the animal body compares favorably with the best modern engines. In addition to performing external work the body must prepare its own fuel store and transport it until needed, make all repairs, and maintain a definite temperature, as well as direct, move and control itself. When all these functions are considered the marvelous perfection of the animal body as a machine¹ becomes apparent."

1. Henry: Feeds and Feeding. Page 88-89.

THE FOOD REQUIREMENTS FOR MAINTENANCE.

The maintenance ration may be defined as one which supplies an amount of digestible protein and net energy equal to the fasting katabolism of the quiescent animal, i.e., a ration just sufficient to prevent any loss or gain of tissue¹ in the animal body. Armsby¹ defines it as follows: "Feed is supplied to the farm animals in order that they may either yield products useful to man as materials for human food and clothing or serve him by the performance of mechanical work. But as a factory must first be supplied with enough power to keep in motion the shafting, belting, and other machinery before any product can be turned out, so the animal mechanism must be provided with sufficient food to maintain the processes essential to life before any continued product is possible. The amount of food required for this purpose is called the maintenance ration of the particular animal. It is the quantity of food necessary simply to support the animal when doing no work and yielding no material product. The maintenance ration keeps the empty machinery running, while the additional feed furnishes the power necessary to turn out the product". So the maintenance requirement may be said to be the 'physiological minimum' on which life may be sustained when the animal is in an absolute state of rest". In practical feeding no such state of complete rest, even if desired, can be maintained for any length of time. Animals are

1. Armsby: Animal Nutrition.

continually making minor movements, such as walking about, stamping, switching their tails, etc. Hence in practical feeding "the expenditure made in this incidental work must be added to the requirement for physiological maintenance. The maintenance requirement plus the requirement for incidental work is called the 'economic maintenance'. In practice it is the economic maintenance which is of importance and it will necessarily be more or less variable according to the individuality of the animal, the conditions under which it is maintained and the conditions of previous feeding."

According to Armsby, fully one-half of the farmer's feed bill is expended for maintenance alone. Since it is usually the aim to feed a little more than maintenance it becomes very necessary from an economic view for the feeder to study the maintenance requirements. Not only is this of fundamental importance but also an understanding of the principles governing the production of meat, milk, wool, or work from the other half of the feed is of great value.

Fasting Katabolism-- The purpose of the fasting katabolism (which is an expression of the maintenance requirement) is to furnish energy for the life actions. The energy is obtained from the materials of the body itself, i.e., in the carbohydrates, fats, and proteins. "The carbohydrates of the body which are stored in the liver and the muscles in the form of glycogen, are the first reserve to be drawn upon during the first few days of fasting. Since this amount is

small it is used up in a short time. Then it is necessary for the fasting animal to draw upon another body substance which we are told is the surplus fat that has been stored in the tissues. It is a commonly observed fact that starving or underfed animals will lose fat to a marked degree".¹

Whether the energy during fasting is supplied principally by the carbohydrates of the body or by the fats, it seems that a certain amount of protein must also be katabolized. The protein katabolism is said to diminish rapidly at first and then more slowly, until, within a few days, it reaches a minimum value where it remains constant for some time. As long as there is a sufficient supply of fat present only a little protein is katabolized.

"Other conditions being equal, the total amount of energy expended in the fasting katabolism is constant in the same individual, whether its source be largely from carbohydrates and fats or largely or entirely from the proteins. Thus the conclusion is reached that fats, carbohydrates, and proteins mutually replace each other as fuel material, as one or other is most available. A certain amount of protein however, is required under any condition. In other words, the energy requirement is constant while the protein requirement may vary depending upon the amounts of fats and carbohydrates available. The feeding organism requires a definite quantity of energy, but seems more or less indifferent to its source".²

1. Henry: Feeds and Feeding.

2. Grindley: Notes from His Lectures to Students on Nutrition.

True Maintenance and Live Weight Maintenance-The maintenance ration has been defined as one which will prevent any loss or gain of tissue in the animal body. Naturally we would conclude that any ration which maintains the weight of the body over a considerable period of time is a maintenance ration. But this does not seem to be true in all cases, especially with growing animals for which a maintenance it would be almost impossible to determine. Waters¹ has shown that the tendency to growth is one of the most marked characteristics of young animals. He fed 15 cattle for considerable periods of time on rations just sufficient to maintain their live weights, but nevertheless as determined by careful measurements of height, depth of chest, and length of head, the animals continued to grow. At the same time there was a considerable loss of body fat, both as judged by the eye and as shown by the appearance and by the chemical composition of the carcass. These rations, therefore, were not real but only apparent maintenance rations. In reality, it seems that there was a consumption of body fat to supply a part of the energy for maintenance while a part of the feed was used for growth, the increase in protein tissue and the accompanying increase in water content masking the loss of fat. Thus, live weight determinations of maintenance, especially with immature animals, may involve considerable error.

From these results we must conclude that in order

1. Henry: Feeds and Feeding. Page 101.

to determine a maintenance requirement for a growing animal it would be necessary to use the results obtained from the respiration apparatus or from the calorimeter as an index of the true maintenance, rather than the live weight of the animal. In more mature animals, the true maintenance and live weight maintenance would probably closely approach each other when measured over long periods, especially when the latter is accompanied by nitrogen equilibrium, i.e. as much protein supplied in the food as was being metabolized in the body. In order to have this condition Armsby thinks that it is not until the food proteids largely exceed the amount metabolized during fasting that nitrogen equilibrium is reached. A small amount he has found to cause a prompt increase in the urinary nitrogen.

Energy Requirement for Maintenance--The maintenance ration as regards energy is usually defined by scientists as one which supplies available energy equal to the fasting katabolism, i.e. a ration just sufficient to prevent any loss of potential energy to the animal body.

Maintenance Requirements of Cattle--It seems that the maintenance requirements of cattle have been more extensively studied than those of other species of farm animals. Unlike other species of animals it is impossible to determine the fasting katabolism of the ruminants on account of the complexity of their digestive apparatus. Hence the method of determining the maintenance requirement is "to

compare the amounts of body energy lost by the animal when fed two different amounts of the same feed, each being less than the maintenance requirement, and computing the maintenance requirement from the difference."¹

Daily Maintenance Requirement of Cattle Per 1000
Pounds Live Weight.

Investigators	Condition of Animal	Number of Animals	No. of Trials	Metabolizable Energy	Net Energy
Armsby	Thin	3	20	11.03	6.25
(Respi.Exps.)					
Kellner(Resp.)	Thin	7	7	10.87	6.29
Do.	Fat	3	3	15.05	8.58
Haecker	Dry Cows	3	5	9.51	5.71
(Calc.by Armsby)					
Evvard	Thin	4	4	10.14	8.11
Evvard	Partly Fattened	3	3		9.07
Moulton(with Waters and Trobridge)	Thin	6	1		6.81 ²
Average of All					
Experiments	Thin			10.4	6.6
	Fat			15.05	8.83

Maintenance Requirements of Sheep--The following table has been calculated by Armsby from the experiments of other investigators. He gives it on the basis of 100 pounds for sheep as well as for swine which may be calculated to a 1000 pound basis if desired:

1. Bureau of Animal Industry. Bulletin 143.
2. From Outside Data.

Daily Maintenance Requirements of Sheep. ¹	
Kind of Experiment and Investigator	Metabolizable Energy.
Respiration Experiments:	Therms.
Henneberg and Stohman	1.48
Henneberg, Fleischer, and Muller	1.36
Hageman	1.22

Average	1.35
Digestion Experiments:	
Wolff, 14 experiments	1.68
Average of All	1.48

Daily Maintenance Requirement of Swine.			
Investigator	Number of Animals	Metabolizable Energy	Net Energy
			Therms
Meissel, Strohmer and Lorenz. (Calc. by Kellner) (Unfatted at Tangl critical T. 20-23 C.)	2		1.27
(Fattened at critical T. 17 C.)	2		1.21
Dietrich (Wts. 50, 100, 150, 200)	4	1.43	
(Wts. 300, 375, 400 lbs)	3	1.77	
(Wts. 325, 425 lbs)	2	1.23	
Average of All		1.48	1.25

Daily Maintenance Requirements of Horses.

Investigator	Number of Animals	Metabolizable Energy	Net Energy
Zuntz and Hageman	Many	11.88	4.08
Wolff	Many	13.99	
Muntz	A number	13.34	
Grandeau and Laclerc (calc. by Armsby)		12.12	
Average of All		12.86	

	SUMMARY.				
	Cattle		Horses	Sheep	Swine
	Thin	Fat			
Metabolizable Energy	10.4	15.05	12.86	1.43	1.48
Net Energy	6.6	8.83	4.08		1.25

Comparing these results it is noticed that the metabolizable energy given for the sheep and the swine, are very close, and for the horse and steer approximately close. To compare the cattle, for example, with the sheep it is necessary to assume that the surfaces exposed by these two species are roughly proportional to the two-thirds powers of their weights. Hence the corresponding maintenance ration for a 1000-pound steer would be $1.43 \times \frac{(1000)^{2/3}}{100}$ or $1.43 \times \sqrt[3]{(10)^2} = 6.62$ therms metabolizable energy as compared with an average of 10.4 therms for cattle. Similar for swine we would have $1.48 \times \frac{(1000)^{2/3}}{100} = 6.85$ therms of metabolizable energy as compared with 10.4 therms for cattle. This is a rough approximation but it nevertheless shows very well that the metabolism of the sheep and the swine per unit of surface

is distinctly lower than that of cattle. The main reasons for these differences seem, as yet, not definitely known.

The Principal Factors Which Affect the Energy
Requirements for Maintenance--These factors seem to be size, muscular activity, temperament, condition, age, and external temperature.

Size-- Judging from the results found with different sizes of animals it seems obvious that large animals metabolize more matter and consequently have a larger maintenance requirement than smaller ones. Hence to get a comparison between individuals of livestock, especially of the same species, it is necessary to use a method of calculation which will meet the conditions. The method suggested by investigators is based on the geometrical fact that "the surfaces of two solids of the same shape are proportional to the two-thirds power of their volumes. If it is assumed that all animals of the same species have the same shape and the same specific gravity, their weights are proportional to their volumes, and their surfaces must be proportional to the two-thirds power of their weights". Thus in a comparison of animals we can use the above statement as a basis for calculation.

Muscular Activity--It has been found that the metabolism of a man lying quietly in bed is 11 per cent greater when he is awake than when he is asleep. If a man is

standing Benedict has found that his metabolism increases 16.5 per cent as compared with his metabolism when he is sitting down. Armsby noticed in one of his experiments that a few flies in the respiration chamber with a horse caused an increase of 10 per cent in the metabolism. It is a well known fact that in fattening cattle the smaller number of movements made by the animals show better and more economical gains. Therefore the maintenance requirements in these various movements would be greatly reduced if the number of activities are lessened.

Temperament--A dairy cow which is a high producer usually shows good angularity and a tendency to much leanness as a result of the expenditure of energy in the manufacture of food products into milk. Thin people are generally of a nervous disposition or have a tendency to worry while fat people are the reverse. Hence a nervous, restless, animal will have a higher maintenance requirement than a quiet animal. This has been tried by Armsby and Fries. They used a pure bred Angus steer having a quiet temperament. They found by means of a respiration calorimeter that the Angus steer required for an average maintenance 5.60 therms while the scrub steer required 6.65 therms of net energy. From these results the conclusion was that "if such animals prove to be characteristic of the two types of animals they will go far toward explaining the economic superiority of the beef type."

Condition--It was shown in previous figures taken from Armsby that the net energy requirement for thin cattle was about 6.6 therms as compared with 8.83 therms for the net energy requirement of the fat cattle. This difference naturally leads us to believe that in the case of cattle, at least, there is some influence on the maintenance requirement.

Age--The age of an animal also has its influence on maintenance requirement as was shown in the case of the growing animal and the mature animal. Again we find an interesting experiment tried by Armsby and Fries¹, in which they determined the requirement of two steers (in the respiration calorimeter) first as yearlings, then as two-year-olds, and later as three-year-olds. In the first trial it was found that the average maintenance requirement of the yearlings was 6.65 therms, for the two-year-olds, 6.04 therms and as three-year-olds, 5.67 therms of net energy per 1000 pounds live weight.

Temperature--From the results of experiments by Voit² and also by Rubner² it is shown that when the external temperature falls below a certain limit the heat production of the animal shows a marked increase. "This point at which the physical regulation gives way to or begins to be supplemented by the chemical regulation is called the 'critical temperature' for the animal. Above this temperature the radiating capacity of the body surface is varied to meet the

varying conditions; below it this method of regulation is largely exhausted, and therefore the heat production is varied to suit the needs. Hence under such conditions the animal must spend energy to meet this need for heat production. The food supplies the energy, so a greater supply is needed.¹" For cattle and sheep this critical temperature, according to investigators, seems to be very low, therefore, this factor would have little effect except in severe winter. Here then, we find the reasons for saying that, generally speaking, the open-shed for feeding cattle is just as economical as the closed barn. In the case of the horse we do not have to notice so closely since the critical temperature is higher than it is for cattle. If there is much change it may have the tendency to increase the maintenance requirement in cold weather. For hogs it is better not to expose them to cold weather.

1. Bu. of Animal Industry. Bul. 143.

THE PROTEIN REQUIREMENT FOR MAINTENANCE.

"While the energy supply of the fasting animal is chiefly derived from the breaking down of the non-nitrogenous material, the functional activity of the tissues necessarily involves the katabolism of a certain amount of protein.¹"

If protein alone is fed it has been found that two and a half to three times the amount of protein katabolized during fasting is required to bring the animal into nitrogen equilibrium, the excess of protein being katabolized to furnish energy. Armsby states that if the ration contains an abundance of carbohydrates the protein requirement for maintenance may equal or even fall below the fasting katabolism.

Thus it seems evident that the relative abundance or scarcity of the supply of non-nitrogenous nutrients may greatly modify the extent and character of the protein metabolism, as well as the amount of the protein requirement. Hence, in calculating the maintenance ration not only the amount of protein but also the supply of non-nitrogenous materials need to be considered.

It is also of interest to note that the feeding of large amounts of protein can not cause any considerable storage of protein in the body; except in the case of immature pregnant, or milk producing animals any excess of protein

1. Bu. Of An. Ind. Bul. 143.

above the maintenance requirement may be utilized to a certain extent at least, as for growth, foetal development, or milk production as the case may be.

Protein Requirement for Maintenance of Different Farm Animals:- For cattle it has been found by scientific investigators, impracticable to ascertain the fasting katabolism of ruminants; their maintenance requirement must, then, be determined by a process of trial. A summary of the data is given in the following table:¹

Protein Requirement for Cattle Per 1000 Pounds
Live Weight.

Investigators	Number of Animals	Crude Protein Pounds	True Protein Pounds
Kuhn and Kellner	8	.74	.60
Armsby	3	.54	.44
Armsby and Fries	3	.53 to .97	.44 to .84
Copenhagen Station	6(milk cows)	.43	
Illinois Station	2(two-year-olds)	.43	

As a conclusion Armsby thinks "it is safe, therefore to estimate 0.6 pound of crude protein or .0.5 true protein per 1000 pounds live weight as representing in a general way the minimum protein requirement of mature cattle with a probable range of .1 or .2 pound either way under varying conditions.

For actual maintenance feeding it is probable that a somewhat more liberal supply of protein than is indicated by these figures would be advisable. Rations so

1. Bu. of An. Ind. Bul. 143.

poor in protein, if containing an adequate amount of non-nitrogenous matter, would probably suffer a loss through failure of the animal fully to digest the non-nitrogenous matter. A somewhat narrower nutritive ration could readily be reached in practice in ordinary feeding without additional expense and from the standpoint of digestibility would very likely be justified".

Protein Requirements for Sheep--The requirement for¹ sheep as given by Schulze and Marcker show an average maintenance requirement of 0.66 pound of digestible crude protein per 1000 pounds live weight. From the results found¹ by Katayama with two sheep 0.41 pound of digestible crude protein(or pure protein since the ration contained minimum amounts of non-protein) per 1000 pounds live weight was apparently sufficient to prevent a loss of nitrogen from the body. But this amount did not include the growth of wool which gives 0.55 pound of digestible pure protein as representing the minimum requirement for the maintenance of mature sheep including the growth of wool. This requirement shows a greater demand than for cattle which is, no doubt, due to the increased amount(0.14) of protein required for the growth of wool.

1. Bu. of An. Ind. Bul. 143.

Protein Requirement of Swine Per 1000 Pounds Live Weight.

Investigators	Number of Animals	Dig. Crude Protein. Pounds.
¹ Meissel, Strohmer and Lorenz	2	0.40
Dietrich	2	0.46
³ McCollum (Fed Starch and Zein for 10 days)	1	0.58
McCollum	1	0.50
Tangl	3	0.44
	1	0.91
² Dietrich	2	0.87
Average		0.60

In conclusion it seems safe to say that 0.6+ pound digestible crude protein per 1000 pounds live weight is sufficient for the maintenance of swine, though if a larger supply of carbohydrates is fed this requirement might go lower but with swine(as Armsby suggested with cattle) it would be more economical to feed a more liberal supply of protein.

⁴ Protein Requirement for Horses--Grandeau and Laclerc report experiments with three horses in which the nitrogen balance was determined, and the results showed an average maintenance requirement of 0.59 pound of digestible crude protein per 1000 pounds live weight.

Factors Affecting the Protein Requirement--It seems quite evident from the reading of the results of these

1. Bu. of An. Ind. Bul. 143.
2. Illinois Bul. 163.
3. Wisconsin Research Bul. 21. 4. Bu. of An. Ind. Bul. 143.

experiments that many factors of importance are to be considered. We do not find the species varying with the surfaces shown by the animals, as in the energy requirements, but the variation is with their live weights, hence, size of animal is important.

Previous Feeding--During the feeding test, to secure data for this thesis, it was noticed that mares when changed to a lower ration, after they had been at constant weights for two or more weeks, soon adjusted their systems to the new ration and continued with the previous constant weight. Similarly, Prof. Eckles observed with experiments on cows that they lived more economically on rations, after adjusting their bodies to the new plane of nutrition, than was apparent at the beginning of the feeding test. Likewise, Dean Waters from the results of experiments with steers, concludes "that the animal organism when kept for a long period of time on a low nutritive plane, gets on a more economical basis than when more liberally fed".

The Composition of the protein is another factor of importance since a number of the proteins may be valuable for maintenance while others are good for production. Referring again to McCollum's experiments with zein and gelatin, he found that they were insufficient for maintenance though combining zein with starch, this ration gave a maintenance for ten days. Gliadin, while being able to maintain the nitrogen equilibrium of the body, is unable to produce

any growth.

¹
Michaud thinks that the protein requirement decreases as the composition of the protein fed approaches the composition of the protein of the body of the animal.

In studying the protein requirements for cattle and also of swine it is noticed that the amount of non-nitrogenous nutrients plays an important factor in the requirement i. e. their relative abundance or scarcity to the cells of the body may cause profound modifications of the protein metabolism. Re¹garding these conditions Armsby makes the following statement:" A lack of readily available non-nitrogenous material in the body tends to increase the protein katabolism above its minimum value. Evidently, then, in seeking to determine the minimum amount of protein required for maintenance, the food given should contain a liberal supply of non-nitrogenous nutrients to supply the necessary energy for the animal, since otherwise there is danger that the protein will be katabolized for this purpose, resulting in an apparent increase of the maintenance requirement."

SUMMARY.

To get a better comparison of the approximate maintenance requirements of farm animals, the following table will be of interest:

1. Bureau of Animal Industry. Buletin 143.

Maintenance Requirements of Farm Animals.

Species	Live Weight Pounds. Pounds	Digestible Crude Protein Pounds	Net Energy Therms	Metabolizab- le Energy Therms
Cattle(Thin)	1000	0.6	6.6	10.4
Cattle(Fat)	1000	0.6	8.83 ¹	15.05
Horses	1000	0.6	7.00 ¹	12.86
Sheep	100	0.066	1.00	1.43
Swine	100	0.06	1.25	1.48

CHANGES IN THE MATERNAL ORGANISM DURING PREGNANCY.

It is commonly believed by scientists that there are present in the maternal organism certain substances called 'harmones' which through their action bring about pregnancy. The exact nature of these substances is not known.

During pregnancy there are numerous anatomical and physiological changes occurring in the maternal organism. They seem to affect not only the generative system but the body in general. They are associated with the supply of nutriment and energy for the formation of a new organism in the uterus, and the preparation for its maintenance in the succeeding period. Just how much strain is added to the mother thru the demands of the nutriment of the foetus and the waste products is not yet known.

The sources of these nutrients which the foetus demands is not conclusively shown but Marshall¹ seems to give the best information available, so far as they have been found by physiologists. "Does the mother deplete her own tissues, or is she content to transfer the unorganized substances, which are absorbed from the food and not yet fixed as vital constituents of the protoplasm? In insufficient nutrition the mother certainly gives up organized tissue-products, and, even with a splendid diet, a period is usually observed during which the mother must draw on her own tissues to account for the loss of nitrogen. On the other hand it is probable that unorganized substances are also utilized by the

1. Marshall: Physiology of Reproduction.

trophoblast, since variations in diet are apparently capable of producing changes in the foetus". He also states that the quality of the ration or food of the mother is directly concerned in the fetal growth, for example, abortion occurred in three out of six pregnant rabbits fed on a rich diet in carbohydrates during the whole period of gestation. Wallace¹ found that cows fed on molasses prove to be uncertain breeders. Heape¹ found that Lincoln Sheep fed solely on turnips are specially liable to abortion.

Noel Paton¹ found that the size of the offspring of the guinea-pig depends very directly upon the diet and nutrition of the mother during pregnancy. "To the physiologist it demonstrates the limitations in the extent to which the tissues of the mother can be utilized for the construction of the embryo. The nourishment of the maternal tissues seems to take precedence over the nutrition of the foetus. The mother appears to pass on the 'surplus' nourishment to the foetus. The better the nourishment of the maternal tissues, the greater the growth of the foetus".¹

The Body-Weight During Pregnancy--Systematic determinations of the body-weight give some idea of the effect of pregnancy on the maternal organism as a whole, though this method is not reliable in all cases.

Protein and Carbohydrate Absorption--Normal, sub-normal and supernormal absorption of protein is reported as occurring in the mother during pregnancy. This variation may be due to a possible difference in the quality of the

proteins fed.

There seems to be a decrease in the absorption of carbohydrates during pregnancy. Starch especially is not absorbed so readily in the stomach during this period. Though little is known regarding the absorption of carbohydrates, there is evidence of a tendency to abortion in certain animals on a diet containing them in excess. Bohr¹ believes the foetus is supplied with energy by combustion of carbohydrates. Ferroni¹ found that the absorption of fats from the intestines is increased during pregnancy, the neutral fats, fatty acids, and soaps contained in the feces being all decreased towards the end of the gestation period. This is the time when the subcutaneous tissues of the foetus receive an abundant supply.

Metals and Salts¹-"Little is known regarding the metabolism of the individual metals and salts. The fixation of mineral elements is slight at the beginning, but becomes active towards the end of the pregnancy. From first to last, about a hundred grammes are transferred from the mother to the human foetus. With a few exceptions, the mineral salts are approximately in the same proportion throughout pregnancy. The exceptions are sodium, potassium, and calcium, of which potassium increases as the flesh increases while the increase of flesh does not effect actual amount of sodium. The increase of the blood gives the increase of the sodium. Calcium increases with the replacement of cartilage by bone.(Hugounenq)"

1. Marshall: Physiology of Reproduction.

The results of the experiments conducted at the Wisconsin¹ Experiment Station indicate that calcium, phosphates and sulphates are drawn from the body of the mother, where the ration has an insufficient supply for milk production. This Station also estimated that 25 per cent of the total calcium in the body was withdrawn to supply the calcium in the milk. It seems plausible that under like conditions it would be possible for sufficient salts to be withdrawn from the mother to supply the foetus.

1. Wisconsin Station. Research Bulletin, Number 5.

EFFECT OF PREGNANCY ON MAINTENANCE REQUIREMENTS OF HORSES.

OBJECT.

TO STUDY THE EFFECT OF PREGNANCY AND SUCKLING
ON THE MAINTENANCE REQUIREMENT FOR MARES..

PLAN.

To maintain two mares, A and B, at as nearly constant weight as possible; one of the mares A to be in heavy foal at the beginning of the test, the other mare B open.

To breed B after A foals, and to continue the maintenance after breeding at as nearly constant weight as possible, allowing for increase in weight due to pregnancy.

After A's foal is weaned, both mares are to be maintained at constant weight as nearly as possible, allowing for added weight of pregnancy.

The experiment to be divided into three parts:

Period 1, B, open, A, in advanced pregnancy.

Period 2, B, in foal, A, nursing and not in foal.

Period 3, B, in advanced pregnancy, A, colt just weaned and not pregnant.

Factors Considered:

Conditions are to be as uniform as possible.

Three digestion trials of ten days each, at different stages are to be run to determine the efficiency of digestion.

Constant Factors:

Kind and quality of ration used.

Kind of animals used, age, and sex.

Daily weights.

Kind and distance of exercise.

Stalls and environment.

Water and salt, kindness, and accuracy
of work.

FEED AND MANAGEMENT.

This experiment was planned and conducted under the direction of the Department of Animal Husbandry. The work of the author consisted in keeping daily records of weights of animals, feed and water, and any noticeable changes or necessary modifications during the feeding period.

The grain and roughage used in the rations were a good quality of oats and bran, and of timothy hay, which were bought on the market. The proportion of grain to roughage for the first three months of the feeding period was 3 to 5; for the next six months a ratio of 3 to 4 was used. The same ratio for each animal was used through the whole time of feeding. It was found necessary to vary the rations during the experiment to suit the requirements of the animals, and an increase was necessary when the mare was suckling the foal, and there was a decrease when on maintenance. When any change in quantity of feed was necessary it was made at least two weeks before any digestion trial, thus giving the animals opportunity to be at constant weight during that time. At all times during the experiment careful attention was given to any gain or loss in weight of the mares, and under such conditions the rations were adjusted to keep the animals at as nearly constant weight as possible.

PHOTOGRAPH OF TWO STANDARD BRED MARES USED IN THE EXPERIMENT
TO DETERMINE THE EFFECT OF PREGNANCY AND NURSING ON THE
MAINTENANCE REQUIREMENT.

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JUNE

Age 12, open.

JILL

Age 11, Advanced Pregnancy.

Photograph Taken April 21, 1914. Trial 1, Part 1.

The animals used in the experiment were two Standard Bred mares of 12 and 11 years of age respectively. They were well matched as a team, except in disposition mare A was slightly more nervous than mare B.

During the feeding trial these mares were weighed daily at 7 A.M., watered and fed, and again watered and fed at 5 P.M. When the weather was warm they ran out in a lot at night and remained in the barn during the day. During cold weather they exercised in the lot in the day and were blanketed in the barn at night. A few days, when the weather was warm, it was necessary to keep animals blanketed in their stalls during the day as a guard against flies. At the time of each digestion trial the mares were kept tied in the stalls, and once each day they were given exercise at a walk of 1 mile. The stalls used for the mares were comfortable box stalls in the horse barn and the environments were favorable for the work. Clean hydrant water was supplied in pails at the time of drinking. Salt was given regularly, and kindness and accuracy of work was observed at all time to get definite results.

In the beginning of the experiment it was thought best to run three digestion trials which would give opportunity to learn the requirements of the animals during the three periods as outlined in the plan. During the digestion trials each day was divided into three shifts, each shift in care of a responsible attendant. All feces were collected and weighed

immediately, and put into a closed top receptacle containing 10 cc. of chloroform. The weight and time of voiding were recorded on a record sheet.

At the end of each day, the whole amount for each animal was again weighed, thoroughly mixed and a proper aliquot taken for a sample and deposited in a receptacle containing 10 cc. of chloroform.

The necessary quantities of feed at the beginning of each trial were weighed for the whole test and a sample of a pint taken of the oats and the bran, and a quantity of hay equal to a peck.

The analyses of the feed and feces were made by the Agricultural Chemistry Department.

EXPERIMENT.

The collection of data bearing upon the problem here studied began April 12, 1914, and ceased January 10, 1915. Reference to the plan will show the general topic of study divided into three parts, each one covering a definite period and presenting different conditions in the two animals studied.

The first period, which covers **Part 1 of the problem**, began April 12, 1914, and closed on the day that **Mare A** gave birth to her foal, May 16, 1914, extending over thirty four days.

The second period covering **Part 2** of the experiment began May 16, 1914, and closed on the day the foal produced by Mare A was weaned, October 2, 1914, extending over one hundred and forty days.

The third period covering **Part 3**, extended from October 2, 1914, the date of weaning the foal from Mare A, until the close of the test which occurred when this Mare's weight became constant, January 10, 1915. The third period thus covered one hundred days.

In presenting the data it has been summarized by ten day periods and grouped into three general groups, each of which covers one part or period of the experiment.

GENERAL DATA ON EXPERIMENT.

Tables 1 and 2 present the feed and water consumed and the average live weights in ten day period of Mare B (June) and Mare A (Jill) for the nine months feeding trial, while Tables 3 and 4 give the digestible nutrients, ^{and} energy value ^{of the feeds} and ^{the} average weights of the animals during the experiment.

Table 5 gives the analyses of the feed used for the entire test, and the analyses of the feces for each digestion trial, Table 6 presenting the analyses on the dry basis.

Table 2A shows the detailed results of the three digestion trials 1, 2, and 3, which may be used as information in studying Tables 3 and 4.

Calculations of the Coefficients and Energy Values:

The method used in calculating the data is that usually followed by the Agricultural Chemistry Department. In using this data the analyses for the Air Dry Material was the basis of calculation. The following calorie factors, from Armsby, were used in calculating the energy values: Calories Per Pound.

Digestible Protein -----1464

Digestible nitrogen-free-extract-----1898

Digestible crude fiber-----1598

Digestible ether extract -----3888

Discussion of Trial No.1:

It is a noticeable fact that pregnant mares tend to take on weight and apparently flesh on the same rations they use when farrow. There are

several factors which might be used to explain this phenomanon

1. They may eat more.
2. They may become more quiet and waste less energy.
3. They may digest more completely.
4. They also drink much water.

The developing foetus adds to the weight of the mother. The foetus, however, is known to contain a large amount of water as shown by the following analysis:

Analysis of A Bovine Foetus*

Full Term Foetus	Foetus 185 Days.
Per Cent	Per Cent
Water -----76.21-----	84.80
Fat ----- 3.18-----	2.36
Protein -----17.46-----	10.46
Ash ----- 3.55-----	1.78
P ₂ O ₅ -----0.85 -----	0.28

Referring again to Tables 1 and 2, it is noticed in Table 2 that the pregnant mare gradually increased in weight up to the time of parturition, while the non-pregnant mare remained fairly constant-the animals being on very nearly the same ration.

* Hogan's Thesis 1912.

TABLE 1.

MARE B.

FEED CONSUMED AND LIVE WEIGHTS*IN TEN DAY PERIODS.
(Pounds)

Period	Period Ending	Weight	Water	Oats	Bran	Hay
PART 1.						
1.	April 15	1068	140	36	18	90
2.	April 25	1073	173	40	20	100
3.	May 5	1070	305	36	18	100
4.	May 15	1080	321	30	15	100
PART 2.						
5.	May 25	1078	415	25	13	100
6.	June 4	1070	400	25	12.5	100
7.	June 14	1066	502	25	12.5	92
8.	June 24	1057	537	25	12.5	80
9.	July 4	1052	750	25	12.5	80
10.	July 14	1046	823	25	12.5	80
11.	July 24	1040	895	30	15	90
12.	Aug. 3	1027	1039	30	15	60
13.	Aug. 13	1015	958	30	15	60
14.	Aug. 23	1025	834	30	15	60
15.	Sept. 2	1039	794	30	15	60
16.	Sept. 12	1030	569	30	15	60
17.	Sept. 22	1025	446	30	15	60
18.	Oct. 2	1035	284	36	18	72
PART 3.						
19.	Oct. 12	1028	259	40	20	80
20.	Oct. 22	1027	394	40	20	80
21.	Nov. 1	1027	377	40	20	80
22.	Nov. 11	1031	335	40	20	80
23.	Nov. 21	1029	239	40	20	80
24.	Dec. 1	1038	274	40	20	80
25.	Dec. 11	1038	246	40	20	80
26.	Dec. 21	1033	217	40	20	80
27.	Dec. 31	1034	269	40	20	80
28.	Jan. 10	1029	284	40	20	80

* Average Weights for Ten Days.

Note-The first 3 days were used in getting started, April 12 to the 15th.

TABLE 2.

MARE A.

FEED CONSUMED AND LIVE WEIGHTS* IN TEN DAY PERIODS.
(POunds)

Period	Period Ending	Weight	Water	Oats	Bran	Hay
PART 1.						
1.	April 15	1184	160	36	18	90
2.	April 25	1190	375	40	20	100
3.	May 5	1195	300	40	20	100
4.	May 15	1202	374	40	20	160

PART 2.						
5.	May 25	1050	677	40	20	135
6.	June 4	1046	664	40	20	150
7.	June 14	1051	802	40	20	150
8.	June 24	1036	806	80	40	150
9.	July 4	1021	843	80	40	150
10.	July 14	1018	924	80	40	150
11.	July 24	1018	855	80	40	150
12.	Aug. 3	1010	1109	80	40	135
13.	Aug. 13	980	991	60	30	120
14.	Aug. 23	958	889	60	30	120
15.	Sept. 2	974	802	60	30	120
16.	Sept. 12	979	666	60	30	120
17.	Sept. 22	994	579	60	30	120
18.	Oct. 2	994	621	66	33	132

PART 3.						
19.	Oct. 12	1008	523	70	35	140
20.	Oct. 22	1016	550	70	35	140
21.	Nov. 1	1016	490	70	35	140
22.	Nov. 11	1033	486	60	30	120
23.	Nov. 21	1024	438	60	30	120
24.	Dec. 1	1030	396	60	30	120
25.	Dec. 11	1025	363	60	30	120
26.	Dec. 21	1020	370	60	30	120
27.	Dec. 31	1029	251	60	30	120
28.	Jan. 10	1029	308	40	20	80

* Average Weights for Ten Days.

TABLE 2A.

GENERAL TABLE ON RESULTS OF EXPERIMENT.

Of The Three Digestion Trials(Of Ten Days Each) Showing Rations Fed, Nutrients Fed Daily, Nutrients Recovered Daily, in Feces, Nutrients Digested Daily, and the Coefficients of Digestibility for Mares A and B. (Nutrients Given in Pounds).

Rations Used During the Ten Day Digestion Trials for Each Month.							
	Mare B				Mare A		
	Apr.	Aug.	Nov.		Apr.	Aug.	Nov.
Oats	4	3	4		4	6	6
Bran	2	1.5	2		2	3	3
Hay	10	6	8		10	12	12

Average Daily				Feces Recovered.	Average Daily		
Pounds: 21.78:19.81:21.90				24.62	:	33.48	:34.92

First Digestion Trial April 26 to 30, 1914.							
Nut's Fed	Daily Nut's	Daily Feces	Nut's Diges.	Coef. of Diges.	Nut's Fed	Daily Nut's	Daily Feces
Dry M.	14.44	4.73	9.708	67.29	14.44	6.109	8.33
Ash	.65	.582	.069	10.59	.65	.584	.067
C. Pro	1.424	.491	.933	65.51	1.424	.531	.893
Fat	.395	.058	.337	85.31	.395	.090	.305
C.Fib.	3.771	1.417	2.354	62.42	3.771	2.213	1.558
N.F.Ex	8.199	2.184	6.015	73.36	8.199	2.691	5.508

Second Digestion Trial August 10 to 20, 1914.							
Dry M.	9.462	5.395	4.067	42.98	18.924	9.127	9.797
Ash	.430	.573	---	---	.86	.987	---
C. Pro.	.979	.352	.627	64.02	1.958	.674	1.284
Fat	.275	.08	.195	70.91	.550	.145	.405
C.Fib.	2.36	2.01	.347	14.70	4.72	3.398	1.322
N.F.Ex	5.41	2.378	3.032	56.04	10.82	3.924	6.896

Third Digestion Trial November 16 to 26, 1914.							
Dry M.	12.72	5.694	7.026	55.23	19.086	9.166	9.92
Ash	.679	.601	.078	11.48	1.019	.867	.152
C.Pro	1.338	.508	.830	62.03	2.007	.923	1.084
Fat	.347	.114	.233	67.14	.520	.157	.363
C.Fib.	3.479	1.984	1.495	42.97	5.218	3.394	1.824
N.F.Ex	6.882	2.487	4.395	63.86	10.323	3.825	6.498

Energy Value in Therms.	
First Trial	17.85
Second Trial	7.98
Third Trial	12.85

15.44
18.657
18.24

TABLE 3.

Mare B

Average Daily: Nutrients Digested in Pounds, Energy Value In Therms, and Live Weight in Pounds for Ten Day Periods.

Period	Ending:	Period:	Nutrients Digested Daily in Pounds.				Energy Value	Average
:	:	:	Protein	Fat	C.Fiber	N.F.Ex.	:Therms	:Period Weight
1.*	April 15		.840	.303	2.118	5.413	16.066	1068Lbs
2.	April 25		.933	.337	2.354	6.015	17.854	1072 "
3.	May 5		.878	.315	2.313	5.772	17.162	1070
4.	May 15		.796	.282	2.251	5.408	16.123	1080
5.	May 25		.717	.214	.519	3.913	10.138	1078
6.	June 4		.712	.212	.518	3.899	10.095	1070
7.	June 14		.712	.212	.518	3.899	10.095	1066
8.	June 24		.681	.204	.481	3.680	9.543	1057
9.	July 4		.636	.192	.427	3.351	8.720	1052
10.	July 14		.636	.192	.427	3.351	8.720	1046
11.	July 24		.740	.225	.484	3.857	10.052	1040
12.	Aug. 3		.627	.195	.347	3.035	7.991	1027
13.	Aug. 13		.627	.195	.347	3.035	7.991	1015
14.	Aug. 23		.627	.195	.347	3.035	7.991	1027
15.	Sept. 2		.627	.195	.347	3.035	7.991	1039
16.	Sept. 12		.627	.195	.347	3.035	7.991	1030
17.	Sept. 22		.627	.195	.347	3.035	7.991	1035
18.	Oct. 2		.752	.234	.416	3.642	9.563	1025
19.	Oct. 12		.830	.233	1.495	4.395	12.852	1028
20.	Oct. 22		.830	.233	1.495	4.395	12.852	1027
21.	Nov. 1		.830	.233	1.495	4.395	12.852	1031
22.	Nov. 11		.830	.233	1.495	4.395	12.852	1031
23.	Nov. 21		.830	.233	1.495	4.395	12.852	1031
24.	Dec. 1		.830	.233	1.495	4.395	12.852	1038
25.	Dec. 11		.830	.233	1.495	4.395	12.852	1038
26.	Dec. 21		.830	.233	1.495	4.395	12.852	1033
27.	Dec. 31		.830	.233	1.495	4.395	12.852	1034
28.	Jan. 10		.830	.233	1.495	4.395	12.852	1029

*Period of 4 days.

Note-See Table 5 for Analyses of Feed and Feces.

TABLE 4.

Mare A

Average Daily: Nutrients Digested in Pounds, Energy Value of Dig. Nutrients in Therms, and Live Weight in Pounds for Ten Day Periods.

			; Period: Nutrients Digested Daily in				: Energy:Aver.	
Period : Ending:			Pounds.				: Value :Period	
			:Protein	Fat	C.Fiber	N.F.Ex.	: Therms:Weight	
1.*	April	15	.804	.274	1.402	4.956	13.889	1184
2.	April	25	.893	.305	1.558	5.507	15.435	1190
3.	May	5	.893	.305	1.558	5.507	15.435	1195
4.	May	15	.893	.305	1.558	5.507	15.435	1202
5.	May	25	1.070	.327	1.361	6.316	17.001	1036
6.	June	4	1.128	.342	1.492	6.783	18.239	1046
7.	June	14	1.128	.342	1.492	6.783	18.239	1051
8.	June	24	1.674	.530	1.676	8.892	24.067	1036
9.	July	4	1.674	.530	1.676	8.892	24.067	1021
10.	July	14	1.674	.530	1.676	8.892	24.067	1018
11.	July	24	1.674	.530	1.676	8.892	24.067	1018
12.	Aug.	3	1.616	.514	1.546	8.425	22.825	1010
13.	Aug.	13	1.285	.405	1.323	6.903	18.672	1010
14.	Aug.	23	1.285	.405	1.323	6.903	18.672	980
15.	Sept.	2	1.285	.405	1.323	6.903	18.672	958
16.	Sept.	12	1.285	.405	1.323	6.903	18.672	974
17.	Sept.	22	1.285	.405	1.323	6.903	18.672	994
18.	Oct.	2	1.424	.446	1.455	7.593	20.555	994
19.	Oct.	12	1.264	.424	2.128	7.580	21.286	1008
20.	Oct.	22	1.264	.424	2.128	7.580	21.286	1003
21.	Nov.	1	1.264	.424	2.128	7.580	21.286	1016
22.	Nov.	11	1.084	.363	1.824	6.497	18.244	1033
23.	Nov.	21	1.084	.363	1.824	6.497	18.244	1024
24.	Dec.	1	1.084	.363	1.824	6.497	18.244	1030
25.	Dec.	11	1.084	.363	1.824	6.497	18.244	1025
26.	Dec.	21	1.084	.363	1.824	6.497	18.244	1020
27.	Dec.	31	1.084	.363	1.824	6.497	18.244	1029
28.	Jan.	10	.723	.242	1.216	4.331	12.163	1029

* Period of 4 Days.

Table 5.

Chemical Analyses of Feed Used and Feces Recovered for
Three Digestion Trials. (Air Dry Material)

	Dry Matter	Ash	Protein	Fat	Crude Fiber	N.F. Ex.	Moisture
Oats	88.80	3.49	12.28	3.94	11.94	57.15	11.20
Bran	88.26	6.11	17.09	4.86	9.01	51.19	11.74
¹ Timothy	91.23	3.90	5.91	1.40	31.13	48.89	8.77
² "	92.59	5.22	6.31	1.15	35.26	44.65	7.41
Feces for First Trial. April 20-30. 1914.							
Mare A	89.91	8.60	7.81	1.32	32.57	39.607	10.09 72.40*
Mare B	89.78	11.04	9.325	1.10	26.89	41.42	10.22 75.80
Feces for Second Trial. August 10-20. 1914.							
Mare A	92.22	9.97	6.806	1.46	34.33	39.65	7.78 70.44
Mare B	91.85	9.75	5.988	1.35	34.27	40.48	8.15 70.37
Feces for Third Trial. November 16-26, 1914.							
Mare A	93.12	8.808	9.38	1.59	34.48	38.85	6.85 71.82
Mare B	93.32	9.856	8.32	1.86	32.52	40.75	6.68 72.14

¹ Timothy hay fed in Trials 1 and 2.

² Timothy hay fed in Trial 3.

*Amount of moisture from the fresh to the air dry basis.

TABLE 6.

Per Cent of Feces and Feed Calculated to a Dry Basis.
(From Analysis of Air Dry Material)

	Dry Matter	Ash	C. Protein	Fat	C. Fiber	N. F. Extract
Oats	88.80	3.93 ✓	13.82	4.44	13.44	53.17
Bran	88.26	6.92	19.36	5.51	10.21	57.99
Timo thy	91.23	4.27	6.47	1.53	34.12	53.58
Timo thy	92.59	5.63	6.81	1.24	38.09	40.82
Feces for First Trial. April.						
Mare A	89.91	9.56	8.688	1.46	36.22	44.05
Mare B	89.78	12.30	10.388	1.225	29.95	46.136
Feces for Second Trial. August.						
Mare A	92.22	10.81	7.38	1.58	37.226	42.999
Mare B	91.85	10.62	6.519	1.47	37.31	44.077
Feces for Third Trial. November.						
Mare A	93.12	9.459	10.069	1.714	37.029	41.729
Mare B	93.32	10.56	8.919	2.000	34.846	43.673

Table 7.

Showing Average Weight, Total Food and Water Consumed, Food and Water Consumed per 1000 Pounds Live Weight per Period and per Day, The Difference in Weight, and Water and Food Consumed. Note (The + Sign Shows Excess of Requirements of A over B).

Part 1:		April 12		to	May 16.	
Condition						
of Animal: Mare B Open.					Mare A in Advanced Pregn.	
		Per 1000	Per Day	Per	Per 1000	Per Day
Average		Pounds	1000	Lbs.:	Pounds	1000
Weight	1072			:	1193	
Total				:		
Water	939	875	25.74	:	1209	32.26
Total				:		
Oats	142	133	3.91	:	156	3.85
Total				:		
Bran	71	66	1.94	:	78	1.91
Total				:		
Hay	390	364	10.70	:	390	9.62

Mare A Consumed More Food on Actual Weight But Less Per 1000Lbs. Difference in Weight, and in Water and Food Consumed, A and B.

	Actual Weight	Per 1000	Per Day	Per 1000
	Lbs.	Lbs.	Lbs.	Lbs.
Weight	+121			
Water	+270	+222		+6.52
Oats	+ 14	- 2		- .06
Bran	+ 7	- 1		- .03
Hay	0	- 37		-1.08

TABLE 8.

Showing Nutrients Fed Daily, Nutrients Recovered Daily, in Feces, Nutrients Digested Daily for Mares A and B, the Difference in Nutrients Digested, and the Coefficients of Digestibility of First Digestion Trial. April 20 to 30, 1914.

Daily Rations.							
Mare B				Mare A			
Oats 4 lbs. Bran 2 lbs.				Oats 4 lbs. Bran 2 lbs.			
Hay 10 lbs.				Hay 10 lbs.			
Feces Recovered.							
Pounds:	21.78	Daily Average		24.62			

Nut's	Nut's	Daily	Nut's	Nut's	Daily	Nut's	Difference
Fed	Fed	Nut's	Diges.	Fed	Nut's	Diges.	in Nutrients
Daily	Daily	Feces	Daily	Daily	Feces	Daily	Diges. Daily

Pounds.				Pounds.			
D. M.	14.44	4.73	9.708	:	14.44	6.109	8.33 1.377
Ash	.65	.582	.069	:	.65	.584	.067 .002
C. Pro.	1.424	.491	.933	:	1.424	.531	.893 .040
Fat	.395	.058	.337	:	.395	.090	.305 .032
C. Fib.	3.771	1.417	2.354	:	3.771	2.213	1.558 .796
N. F. Ex	8.199	2.184	6.015	:	8.199	2.691	5.508 .507
Therms			17.85	:		15.44	2.41

Coefficients of Digestibility.

	Dry M.	Ash	Protein	Fat	C. Fiber	N. F. Extract.
Mare A	57.69	10.29	62.71	77.21	41.31	67.17
Mare B	67.29	10.59	65.51	85.31	62.42	73.36

Tables 7 and 8 give a summary of the results of Part 1. It will be noticed from Table 7, that the pregnant Mare A had an average weight of 121 pounds more than Mare B. She consumed 270 pounds more water, an equal quantity of hay, 14 pounds more oats and 7 pounds more bran than the non-pregnant Mare B. But when these data are reduced to the basis of food consumed per unit of weight, it will be seen that the pregnant Mare A consumed 2 pounds of oats, 1 pound of bran, and 37 pounds of hay less per 1000 pounds live weight during the period than the non-pregnant Mare B. Similarly, it is found that Mare A consumed .06 pound of oats, .03 pound of bran, and 1.08 pound of hay less than did Mare B per day per 1000 pounds.

It should be remembered that the pregnant Mare A was of such a disposition that she took more exercise than Mare B, which would require a greater expenditure of energy.

Table 8 shows that Mare A consumed per day of the digestible nutrients:

(Dry Matter -----	1.3777	pound.)
(Ash-----	.002	"
Protein-----	.040	"
Fat -----	.032	"
C. Fiber -----	.796	"
N. F. Extract-----	.507	" less than Mare B.

Similarly, this table shows that she has a lower

coefficient of digestibility for each nutrient in the feed, which indicates that the pregnant animal has digested a smaller percentage of her food than the non-pregnant animal.

Summary-- The results of this part of the experiment may be summarized as follows:

(1) That the pregnant mare increased in weight up to the time of parturition, on very nearly the same ration as she used when farrow.

(2) That the pregnant mare used less feed, to maintain the same weight, than the open mare.

(3) That the comparative nervous disposition of Mare A led to a greater amount of exercise than Mare B which was open.

(4) That Mare A including her foetus made an actual gain in weight of 18 pounds in the last 30 days of her gestation period on slightly less feed per 1000 pounds live weight than was consumed by the open Mare B which made an actual gain of 12 pounds during the same time.

TABLE 9.

Showing Average Weight, Total Food and Water Consumed, Food and Water Consumed per 1000 Pounds Live Weight Per Period and per Day, the Difference in Weight, and Water and Food Consumed. Note(The + Sign Shows Excess of Requirements of A over B)

Part 2:	May 16	To	October 2
Condition			
of Animal:	Mare B in Early Pregnancy	:	Mare A, Nursing Foal not Pregnant
Average Weight	1043		
Total			
Water	8336	7992	57.08 ; 11228 11127 79.84
Total			
Oats	396	380	2.71 : 866 858 6.13
Total			
Bran	198	189	1.35 ; 433 429 3.06
Total			
Hay	1074	1020	7.29 : 1872 1854 13.24

Mare A Weighs Less But Consumes More Water and Food.

Difference in Weight, and Water and Food Consumed.

Actual Weight Per 1000 Lbs. Per Day Per 1000 Lbs.

Weight	-34		
Water	+2892	+3135	+22.40
Oats	+ 470	+ 478	+3.42
Bran	+ 235	+ 240	+1.71
Hay	+ 798	+ 834	+5.95

TABLE 10.

Showing Nutrients Fed Daily, Nutrients Recovered Daily, Nutrients Digested Daily for Mares A and B, The Difference in Nutrients Digested, and the Coefficients of Digestibility of Second Digestion Trial. August 10 to 20. 1914.

Daily Rations.

Mare B		Mare A	
Oats 3 lbs.	Bran 1.5 lbs.	Oats 6 lbs.	Bran 3 lbs.
Hay 6 lbs.		Hay 12 lbs.	

Feces Recovered.

Pounds:	19.81	33.48
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Nut's Fed	Nut's Daily	Nut's in Daily Feces	Daily Diges.	Nut's Fed	Nut's in Daily Feces	Nut's in Dig. Daily	Difference in Nutrients Digested
-----------	-------------	----------------------	--------------	-----------	----------------------	---------------------	----------------------------------

D. M.	9.462	5.395	4.067	:	18.924	9.127	9.797	5.730
Ash	.430	.573	----	:	.86	.987	-----	-----
C. Pro.	.9794	.352	.627	:	1.958	.674	1.284	.658
Fat	.275	.08	.195	:	.550	.145	.405	.210
C. Fib	2.36	2.01	.347	:	4.72	3.398	1.322	.975
N.F.Ex	5.41	2.378	3.032	:	10.82	3.924	6.896	3.864
Therms			7.98	:		18.657	10.68	

Coefficients of Digestibility.

	Dry M.	Ash	Protein	Fat	Crude Fiber	N. F. Extract
Mare A	51.77	----	65.59	73.63	28.01	63.73
Mare B	42.98	-----	64.02	70.91	14.70	56.04

Discussion of Part 2-Trial No. 2:

The data presented in Tables 9 and 10, covering the second part of the experiment, during which Mare A was nursing and Mare B was in early pregnancy, show, first, that Mare A had an average weight of 34 pounds less than Mare B, and consumed, per day per 1000 pounds live weight 22.4 pounds of water, 3.42 pounds of oats, 1.71 pounds of bran, and 5.95 pounds of hay more than Mare B, which was in early pregnancy.

Second, That Mare A digested daily of

	Pounds
Crude Protein	.658
Fat	.210
Crude Fiber	.975
N. F. Extract	3.864 more

than Mare B, which shows that, although her ration was double that of Mare B, she digested slightly more than twice as much.

Third, It is noticed, further, that the energy value of nutrients digested by Mare A is 2.67 therms more than double that of Mare B, and for each nutrient digested Mare A shows an average coefficient of digestibility of 6.81 per cent higher than that of Mare B.

Summary--These results may be summarized as follows

(1) That Mare A digested a higher percentage of her food than did Mare B.

(2) That Mare A consumed more water and a larger quantity of grain and hay than Mare B, but during that period she nursed a foal and maintained her weight at slightly less number of pounds than that of Mare B.

(3) In spite of the fact that Mare A received twice as much feed as Mare B her per cent of utilization of the 'fuel value' was 16.72 per cent better.

TABLE 11.

Showing Average Weight, Total Food and Water Consumed, Food and Water Consumed per 1000 Pounds Live Weight per Period and per Day, the Difference in Weight, the Water and Food Consumed.

Note (The + Sign Shows Excess of Requirements of A over B).

Part 3: October 2 to January 10

Condition

of Animal: Mare B in Medium Pregnancy.

Mare A, Colt Weaned, and not Pregnant.

Average Weight	1031	MARE B Per 1000 lbs.	Per Day Per 1000lbs. :	1021	MARE A Per 1000lbs.	Per Day Per 1000
Total			:			
Water	2894	2807	28.07	4175	4089	40.89
Total			:			
Oats	400	388	3.88	610	597	5.97
Total			:			
Bran	200	194	1.94	305	298	2.98
Total			:			
Hay	800	776	7.76	1220	1194	11.94

"MARE A "Weighed Less But Consumed More Water and Food.
Difference in Weight, and in Water and Food Consumed.

Actual Weight Per 1000lbs. Per Day Per 1000 lbs.

Weight	-10		
Water	+1281	+1282	+12.82
Oats	+ 210	+ 209	+ 2.09
Bran	+ 105	+ 104	+ 1.04
Hay	+ 420	+ 418	+ 4.18

TABLE 12.

Showing Nutrients Fed Daily, Nutrients Recovered Daily in Feces, Nutrients Digested Daily for Mares A and B, the Difference in Nutrients Digested, and the Coefficients of Digestibility for Third Digestion Trial. November 16 to 26, 14.

Daily Rations.								
Mare B				Mare A				
Oats 4 lbs. Bran 2 lbs.				Oats 6 lbs. Bran 3 lbs.				
Hay 8 lbs.				Hay 12 lbs.				
Feces Recovered.								
Pounds:	21.90				34.92			
Nut's	Nut's Daily Fed	Nut's Daily Feces	Nut's Daily Diges.	:	Nut's Daily Fed	Nut's Daily Feces	Nut's Daily Diges.	Difference in Nutrients Diges. Daily
Dry M.	12.72	5.694	7.026	:	19.086	9.166	9.92	2.894
Ash	.679	.601	.078	:	1.019	.867	.152	.074
C. PrO.	1.338	.508	.830	;	2.007	.923	1.084	.254
Fat	.347	.114	.233	:	.520	.157	.363	.130
C. Fib.	3.479	1.984	1.495	:	5.218	3.394	1.824	.329
N.F.EX.	6.882	2.487	4.395	:	10.323	3.825	6.498	2.103
Therms			12.85	:			18.24	5.39

Coefficients of Digestibility.						
	Dry M.	Ash	Protein	Fat	C. Fiber	N. F. Extract.
Mare A	51.97	14.91	54.01	69.80	34.95	62.94
Mare B	55.23	11.48	62.03	67.14	42.97	63.86

Discussion of Part 3-Trial No. 3:

From a study of the Tables 11 and 12, showing the results of Part 3, when Mare A was open and just recovering from suckling, and Mare B in medium pregnancy, it will be seen, first, that Mare A, consumed per day per 1000 pounds live weight,

Water	12.82 pounds.
Oats	2.09 "
Bran	1.04 "
Hay	4.18 " more than Mare B,

and had an average weight of 10 pounds less than Mare B.

Second, That Mare A, although she had one-half greater ration during the trial, digested .619 pound per day of total nutrients less than 50 per cent above the nutrients digested by Mare B.

Third, That Mare A, which was open, digested a smaller percentage of nutrients than Mare B, which was in medium pregnancy.

Summary--These results show,

(1) That Mare A, open, consumed a larger percentage of food on basis of actual weight, and per day per 1000 pounds live weight, but digested a smaller percentage of nutrients in her ration than Mare B in medium pregnancy. This shows a condition reverse to that of Part 1 in which the pregnant Mare A digested her feed less efficiently than the open Mare B.

than mare B. - A is more nervous than B, when A was nursing she has a very much better efficiency. No similar record on B.

*This table really follows the
discussion on 60 + 61*

-59-

TABLE 13.

A Comparison of Trials 1, 2, 3, of the Experiment, of Mare B
when Open, in Early Pregnancy, and in Medium Pregnancy.

Part 4.		Rations Used.					
	April		August		November		
Oats	4		3		4 pounds.		
Bran	2		1.5		2 "		
Hay	10		6		8 "		

		Feces Recovered.					
Dry M.	4.73 lbs.		5.395 lbs.		5.694 lbs.		
Fresh:	21.78 "		19.80 "		21.90 "		

	Dry M.	Ash	C. Protein	Fat	C. Fiber	N.F.Ex	Weight

Nut's 1.	14.44	.651	1.424	.395	3.771	8.199	1074
Fed 2.	9.46	.430	.9794	.275	2.36	5.41	1020
Daily 3.	12.72	.679	1.338	.347	3.479	6.88	1030

Daily 1.	4.73	.582	.491	.058	1.417	2.184	1041 AV
Nut's 2.	5.395	.573	.352	.08	2.013	2.378	
in							
Feces 3.	5.694	.601	.508	.114	1.984	2.487	

Nut's 1.	9.708	.069	.933	.337	2.354	6.015	17.85

Diges. 2.	4.067	---	.627	.195	.347	3.032	7.98
Daily 3.	7.026	.078	.830	.233	1.495	4.395	12.85

Coefficients of Digestibility.

Part 1.	67.22	10.59	65.51	85.31	62.42	73.36
Part 2.	42.98	-----	64.02	70.91	14.70	56.04
Part 3.	55.23	11.48	62.03	67.14	42.97	63.86

DISCUSSION NO.4:

A Comparison of Parts 1, 2, and 3. of the Experiment. for Mare B, which shows,

First, Mare B, when open.

Second, Mare B in early pregnancy.

Third, Mare B in medium pregnancy.

Table 13, presents the data of Mare B, for digestion trials, 1, 2, and 3, showing the actual average live weight, the daily rations and nutrients, the daily feces recovered and nutrients, the daily nutrients digested, the coefficients of digestibility and energy values.

It will be seen , first, that the ratio of nitrogenous concentrates to the roughages in the ration of Mare B did not vary a great deal for the three parts, Neither is there a great variation in the feces recovered, considering the decrease in ration used during second and third trials. But in the nutrients digested there is much variation. There are many factors whose influence we are not able to measure. There may have been a mutual replacement of the carbohydrates, fats, and proteins; there may have been an increase or decrease of the salts. There may have been many external factors of great influence.

Reference to the coefficients of digestibility shows that Mare B, digested the highest percentage of nutrients when open, that during early pregnancy a lower

percentage for each nutrient is noticeable. During the period of medium pregnancy there is a very definite decrease in fat and crude protein, a marked increase in crude fiber, an increase in dry matter and nitrogen-free-extract above that of early pregnancy but still a lower percentage than digested when open.

Summary--The data given for Mare B shows, first, that she digested the largest percentage of her food when open.

Second, That she digested(omitting the ash and fat for Part 3) the next highest when in medium pregnancy, and the least when in early pregnancy.

TABLE 14.

A Comparison of Trials 1, 2, and 3, of the Experiment, of Mare A, when in Advanced Pregnancy, Nursing and Open, and Colt Weaned and Open.

Part 5.		Rations Used.			
	April		August		November
Oats	4		6		6
Bran	2		3		3
Hay	10		12		12

	Pounds	Feces Recovered. Pounds	Pounds
Fresh:	24.62	33.48	34.92
Dry M.:	6.109	9.127	9.166

	Dry M.	Ash	C. Protein	Fat	C. Fiber	N. F.	Ex. Weigh
Nut's 1.	14.44	.651	1.424	.395	3.771	8.199	1046
Fed 2.	18.92	.86	1.9588	.55	4.72	10.82	966
Daily 3.	19.08	1.019	2.007	.520	5.218	10.323	1021
						Av.	1011
Daily 1.	6.109	.584	.531	.090	2.213	2.691	
Nut's 2.	9.127	.987	.674	.145	3.398	3.924	
in							
Feces 3.	9.166	.867	.923	.157	3.394	3.825	

							Therms
Nut's 1.	8.331	.067	.893	.305	1.558	5.508	15.44
Diges. 2.	9.797	----	1.284	.405	1.322	6.896	18.657
Daily 3.	9.92	.152	1.084	.363	1.824	6.498	18.24

Coefficients of Digestibility.						
Part 1.	57.69	10.29	62.71	77.21	41.31	67.17
Part 2.	51.77	-----	65.59	73.63	28.01	63.73
Part 3.	51.97	14.91	54.01	69.80	34.95	62.94

Discussion of Part 5:

A Comparison of Trials 1, 2, and 3, of the Experiment for Mare A, which shows,

First, Mare A, in advanced pregnancy.

Second, Mare A, Nursing foal and open.

Third, Mare A, foal weaned and open.

Table 14 gives a comparison of Trials 1, 2, and 3, of Mare A, similar to that given for Mare B in Table 13.

It will be seen that an increase of 2 pounds of oats, 1 pound of bran, and 2 pounds of hay was necessary for Mare A while nursing foal, and the same requirements were needed after foal was weaned until Mare A recovered from her lactation period. It will also be noticed that the ratio of feed to the feces was as 2 to 3+ for each Trial (fresh basis).

For the nutrients digested daily, there seems to be about 1 pound of dry matter digested for each 2 pounds fed.

For the crude protein the highest percentage is shown during the period of suckling, the next highest in advanced pregnancy, the lowest percentage after foal weaned. For fat there is shown a decrease from pregnancy to the period of openness. In the case of crude fiber, and

nitrogen free extract, an approximate uniformity is noticed for each of the three trials.

A study of the coefficients of digestibility shows that there was a uniformity of digestion of dry matter for the three trials, the second and third being practically the same percentages, even if an increase in the ration was necessary during Trials 1 and 2.

The largest percentage of protein was digested during suckling, the next in order during advanced pregnancy while the lowest percentage is found when the mare is recovering from lactation. For the fat and nitrogen-free-extract there is a gradual decrease from Trial 1 to Trial 3.

The percentage of crude fiber is shown to be the lowest during Trial 2, medium in Trial 3, and the highest percentage in Trial 1.

SUMMARY:

Summarizing these results, it seems, First That Mare A digested the dry matter during the period of advanced pregnancy more efficiently than during Trials 2 and 3.

Second, Her efficiency of digestion was practically the same during nursing and while recovering from the lactation period.

Third, The efficiency of digestion of fat and nitrogen-free-extract was highest when Mare A, was in the stage of advanced pregnancy, and decreased gradually

through nursing and recovery from lactation period. The crude protein was digested most efficiently during nursing, second during advanced pregnancy, and least efficiently while recovering from lactation. The crude fiber was digested most efficiently during advanced pregnancy with a marked decrease while nursing and a less noticeable decrease when recovering from lactation.

Fourth, That Mare A, which was of a nervous disposition digested her feed during the experiment more uniformly than Mare B.

Fifth, It was a noticeable fact that more nutrients were required while nursing and during the recovery from lactation than in advanced pregnancy.

Both A & B show a decreased efficiency in 2^d trial - May not this be seasonal,

A's efficiency compared to B's during second trial is remarkable especially when compared with the added quantity of the ration - What is the relation between lactation and digestion?
With A the added ration depresses the digestion
With B a decreased ration " " "
other factors however are not constant.

→ Pounds:

1280
1270
1260
1250
1240
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970

+ MARE A FOAL
O MARE B'S WEIGHT THEN.
X MARE A'S FOAL WEANED.
Z MARE B'S WEIGHT THEN.

PLATE I.

A graphic comparison of Mare A and B, is shown in Plate 1, which is plotted from the last two columns of Tables 3 and 4. The red and black lines give a comparison of Mares A and B on the basis of energy value, which shows, first, that Mare A after parturition (May 16) made a gradual increase in energy requirements up to June 24; after which there are gradual changes due to the weather, the growth of the foal, and her recovery after it is weaned, until Mare A having her ration gradually reduced to that of Mare B becomes constant in weight January 10, 1915.

Mare B starting on the same ration, but open, shows a lower energy requirement after gestation begins (May 22) a decline during warm weather, with a slight increase in October and November but not going back to the requirements when she was open. This curve shows a lower energy value during the experiment but it should be remembered that her conditions were different from those of Mare A.

The broken lines give a comparison of the weights showing that Mare A made gradual gains in body weight up to parturition (which is somewhat different to the experiment of Professor Eckles where a cow made gradual gains up to the latter part of the eighth month, after which there was a

tendency to lose weight) a decline in weight is then noticed until the latter part of August followed with a gradual increase.

Mare B shows a decrease during hot weather but there was a tendency to increase at the close of the experiment due to the gain during pregnancy and cool weather.

From this plate it can be seen that the therm curves did not raise with the weight curves for Mare A. This when taken into account with other facts already presented shows that Mare A did not require extra feed for developing the foetus.

SUMMARY.

A. Comparison of Live Weights and feeds for Both Mares During
Part 1.

1. The pregnant mare increased in weight up to the time of parturition on very nearly the same ration that maintained her weight when farrow; while the open mare consumed the same amount of feed and gained less.

B. Comparison of Mares in First Digestion Trial of Part 1.

2. The pregnant mare A consumed per day a smaller quantity of digestible nutrients per 1000 pounds than the open mare B.
3. Table 8, shows that Mare A has a lower coefficient of digestibility for each nutrient in the feed than the open Mare B.

C. Comparison of Live Weights and Feeds for Both Mares During
Part 2.

1. Mare A consumed more water and a larger quantity of grain and hay than Mare B, but during that period she nursed a foal and maintained her weight 34 pounds less than the weight of Mare B.

D. Comparison of Mares in the Second Digestion Trial. Part 2.

2. Mare A has a higher coefficient of digestibility for each nutrient than that of Mare B.
3. In spite of the fact that Mare A received twice as much feed as Mare B her per cent of utilization of the 'fuel value' is 16.72 per cent better.

E. Comparison of Live Weights and Feeds for Both Mares
During Part 3.

1. Mare A, open, consumed a larger quantity of food with an average weight of 10 pounds less than that of Mare B.

F. Comparison of Mares in Third Digestion Trial. Part 3.

2. Mare A, open, has a lower coefficient of digestibility for each nutrient, except ash and fat, which are higher than that of Mare B.
3. Although Mare A consumed a ration equal to 150 per cent of that of Mare B, she digested in dry matter only 141.19 per cent. of that of Mare B.

G. Comparison of Trials 1, 2, and 3, of Mare B.

1. The coefficients of digestibility show that Mare B digested the highest percentage of nutrients when open; in early pregnancy a lower percentage is found, while in medium pregnancy a still lower decrease in crude protein and fat is shown, with an increase in dry matter, crude fiber, and ether extract, but still lower than digested when open. (The crude protein and fat decreased gradually from the period of openness to medium pregnancy). The crude fiber for Trial 2 is very low-the reason for this decrease is not known.

2. Nutrients Digested Daily Per 1000 Pounds for Mare B

Are as Follows:

	Trial 1.	Trial 2.	Trial 3.
Dry Matter	9.072	3.960	6.814
Ash	.065	----	.076
Crude Protein	.872	.611	.805
Fat	.315	.190	.226
Crude Fiber	2. 200	.338	1.450
N. F. Extract	5.621	2.952	4.262

1. The protein for Trial 1, and Trial 3 are practically the same with a decrease in Trial 2.

2. The maintenance requirement in dry matter for Mare B, in August is only 43 per cent of what it was in April, that is, total digestible dry matter.

H. Comparison of Trials 1, 2, and 3 for Mare A.

1. The Coefficients of Digestibility of Mare A show that she digested the highest percentage of nutrients in advanced pregnancy, except crude protein which is 2.88 per cent higher while nursing and open. During nursing she shows the next highest coefficient of digestibility, except for the dry matter which is almost the same, and for the crude fiber which is 6.94 pounds greater when foal is weaned. The lowest coefficients of digestibility (except dry matter and crude fiber) are found in Part 3, when foal is weaned.

2. Nutrients Digested Daily Per 1000 Pounds for Mare A,
Are as Follows:

	Trial 1.	Trial 2.	Trial 3.
Dry Matter	7.00	9.997	9.687
Ash	.056	---	.148
Crude Protein	.750	1.310	1.058
Fat	.256	.413	.354
Crude Fiber	1.309	1.349	1.781
N.F. Extract	4.628	7.037	6.346

This table shows that the smallest quantity digested is in pregnancy, while during nursing and after foal is weaned, there is a noticeable increase for all the nutrients digested. The crude fiber has remained fairly uniform during the experiment.

I. Evidently from these data the digestibility is greatly influenced by the conditions of Mare A.

J. Comparison of Mares in a General Way for the Three Trials.

1. The mares, when open, utilize more energy than when pregnant.
2. The pregnant mares use less feed to maintain the same weight than the open mares.
3. The digestion coefficients of Mare A indicate that she made more efficient use of her feed when pregnant and suckling than when open and dry; Mare B, however, had a higher digestion coefficient when open than in either early or medium pregnancy.

K. Comparison of These Results with Those Found in Other
Investigations:

Other Investigations*	Pounds	Mare A			Mare B		
		Trials 1	2	3	1	2	3
Digestible Protein	.6	.75	1.31	1.058	.882	.611	.805
Energy Value	12.86	12.97	19.003	17.81	16.68	7.78	12.46

1. The digestible protein is somewhat higher for Mare A in Trial 1, and approximately doubled in Trial 2 and 3.

For Mare B, in Trial 2, there is a marked variation, while in Trials 1 and 3, there is .2 pound higher.

The energy value for Mare A in advanced pregnancy and Mare B in medium pregnancy is practically the same, with a noticeable variation in Trials 2 and 3 of Mare A, and Trials 1 and 2 of Mare B.

* See Page 34.

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1. University of Wisconsin.
2. University of Illinois.

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UNIVERSITY OF MISSOURI
COLUMBIA

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
DEPARTMENT OF AGRICULTURAL CHEMISTRY

May 20, 1916.

Dean Walter Miller,
Graduate School.

Dear Dean Miller:

I have examined the thesis of Mr. E. L. Harrison on
'A study of the effect of pregnancy and of nursing upon
the maintenance requirements of mares', and am satisfied
that it is of a satisfactory character to fulfil the re-
quirement for the Master's thesis.

Mr. Harrison has corrected the errors in calculating
his data as submitted last year and has rewritten his conclu-
sions, making it a very acceptable thesis.

Yours truly,

O. F. Frowbridge

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