ELEVENTH ANNUAL REPORT

OF THE

AGRICULTURAL EXPERIMENT STATION

OF THE

UNIVERSITY OF MINNESOTA.

Fiscal Year July 1, 1902, to June 30, 1903.

ST. PAUL, MINN.:
THE PIONEER PRESS COMPANY,
1904.

UNIVERSITY OF MINNESOTA.

☞ The bulletins of this Station are mailed free to all residents of the State who make application for them.

MINNEAPOLIS, MINN., July 1, 1903.

To His Excellency, Samuel R. Van Sant, Governor of Minnesota:

I have the honor to transmit to you herewith the annual report of the Agricultural Experiment Station of the University of Minnesota for the fiscal year ending June 30, 1903.

GREENLEAF CLARK,
President Board of Regents.

List of bulletins published during the fiscal year ending June 30, 1903.

REPORT OF THE DIRECTOR OF THE EXPERIMENT STATION.

To the President of the Board of Regents:

I have the honor to transmit herewith the eleventh annual report of the Agricultural Experiment Station of the University of Minnesota, in accordance with the act of congress of March 2, 1887, establishing the station, giving somewhat in detail the work accomplished here, and at the farm of O. C. Gregg, superintendent of the Farmers' Institute of Minnesota, near Lynd, Lyon county; also of the stations established by an act of the legislature in 1895—one located near Crookston and one near Grand Rapids. This report includes bulletins 77, 78, 79, 80, 81 and 82, published during the government fiscal year, July 1, 1902, to June 30, 1903, inclusive; and a full account of the disposition of the annual appropriation from the U. S. government, as well as of the amount received from the current expense fund of the University.

In carrying on the experiment work the Hatch fund of $15,000, received from the United States government, has been supplemented by $33,882.06 from the current fund of the University. Following this report is a financial statement of the Northeast and Northwest farms that are maintained by special appropriations made by the legislature.

The Minnesota Agricultural Experiment Station,
In account with
The United States Appropriation, 1902-1903.

DR.

To receipts from the treasurer of the United States, as per appropriation for fiscal year ending June 30, 1903, as per act of congress, approved March 2, 1887		$15,000.00

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By Salaries	$10,507.38	
Labor	2,129.00	
Publications	607.70	
Postage and stationery	95.21	
Freight and express	.....	
Heat, light, water and power	48.53	
Chemical supplies	.....	
Seeds, plants and sundry supplies	236.38	
Fertilizers	.....	
Feeding stuffs	1,129.55	
Library	.....	
Tools, implements and machinery	60.25	
Furniture and fixtures	.....	
Scientific apparatus	.....	
Live stock	186.00	
Traveling expenses	.....	
Contingent expenses	.....	
Buildings and repairs	.....	
Balance	$15,000.00	$15,000.00

FINANCIAL STATEMENT.

Statement of disbursements and receipts of the Minnesota Experiment Station for the twelve months beginning July 1, 1902, and ending June 30, 1903, inclusive.

	Disbursements.	Receipts.	Cash Outlay.
Station	$15,374.88	$666.65	$14,708.23
Agriculture	14,348.00	1,729.34	12,618.66
Horticulture	3,787.07	1,102.90	2,684.17
Chemistry	3,059.81	5.70	3,054.11
Entomology	1,270.38	.....	1,270.38
Veterinary	2,070.00	279.29	1,790.71
Dairy	1,200.00	.....	1,200.00
Animal Husbandry	16,522.33	5,488.94	11,033.39
Coteau	522.41	.....	522.41
	$58,154.88	$9,272.82	$48,882.06
Crookston	7,499.88	2,485.67	5,014.21
Grand Rapids	5,521.03	1,398.16	4,122.87
	$13,020.91	$3,883.83	$9,137.08

DIVISION OF AGRICULTURE.

In 1903 the weather conditions were not so favorable as usual for field and crop experiments. Storms during and after harvest made it very difficult to properly save part of the grain and forage crops under experiment. Chinch-bugs very seriously interfered with the breeding nursery, and with field variety tests of spring wheats, also with the wheat experiments on the general theory of breeding. The cold, wet season and the early frosts resulted in loss in some of the experiments with corn, but in some ways assisted in the selection of corn suited to our northern conditions. On the whole, the work with breeding, farm management, statistical investigations and devising new methods of teaching farm management, and of coöperative breeding is progressing most satisfactorily.

Experiments on the introduction of agriculture into the rural schools are also progressing in a promising manner. Bulletins on seed wheat, alfalfa, corn, bromus and farm management are being prepared for publication. Under the coöperative arrangement with the United States Department of Agriculture, results have accumulated which justify the preparation of a bulletin on statistical methods in plant breeding, and another on statistical investigations in farm management, for publication by the national department.

The experiments in breeding all the leading field crops of Minnesota, and the investigations in methods of breeding plants are progressing most satisfactorily. Some of the methods and machinery devised for breeding these crops are being adopted by other stations and by the U. S. Department of Agriculture, thus giving evidence of the value of this work. The varieties of corn, spring and winter wheat, flax seed, also fiber, peas, oats, alfalfa, barley, millet and other crops which are being originated by selection and by hybridizing, followed by selection, are giving abundant evidence that this work is already adding annually thousands of dollars to the crops of the state, and will soon be adding millions. The development of breeding upon a basis comparable with modern manufacturing is an achievement which the station can properly claim as a result of its investigations along this line. The knowledge of how to breed plants is being rapidly acquired. Investigations long since begun in the study of animal breeding promise as important results along that line as are being reached in plant breeding. Coöperation in breeding plants has been begun with farmers throughout the state, as well as with experiment stations of the surrounding states and the U. S. Department of Agriculture. There is in the hands of Minnesota farmers sufficient seed of Minnesota No. 169 wheat and of Minnesota No. 163 wheat to sow thousands of acres in 1904. Since these wheats add two or three bushels per acre to the yields produced by the old varieties they are already contributing large sums to the value of the annual wheat crop. Minnesota No. 13 corn and some of the varieties of oats and barley, which have been tested for years and distributed by the station, are also widely used throughout the

state, and the total increased annual product already approaches a million dollars in value. Numerous former students of this department and other farmers are beginning to coöperate in the breeding of corn. The investments intelligently made in breeding certainly pay to the state a very large dividend, and lands and other equipment needed to enlarge this work should be supplied. The U. S. Department of Agriculture is encouraging the state to enlarge its breeding operations by meeting any increase on the station's part with further assistance from the appropriations made by the national congress.

The coöperative statistical invesigations begun in 1902 by this division and the Bureau of Statistics of the United States Department of Agriculture in Rice, Lyon and Norman counties have progressed most satisfactorily. From simply collecting data on the cost of growing field crops, the work has developed and now includes collecting all available facts concerning the production, marketing and sale of products, the expenses of the family, and the general profits of the entire farm enterprise. To enable the route men to broaden the scope of the data secured, the number of farms on each route has been reduced from fifteen to eight. The United States Department of Agriculture shows its appreciation of this work by paying its share of the expenses, including a small fee to each farmer and to each farmer's wife for their assistance in weighing food stuffs, produce used in the household, etc. These investigations are a part of a general attempt begun by this institution ten years ago, to develop the facts necessary to use in effectively teaching farm management in schools for farmers.

The first ten years of the experiments dealing with the rotation of crops has now been about completed and the results are being compiled for publication.

Experiments at Coteau Farm, in Lyon County, Southwestern Minnesota, during the ten years, 1894 to 1903 inclusive, developed the fact that experiments are needed to work out systems of crop rotation and farm management suited to the drier areas of our country. In dry years in Minnesota, securing the entrance of water into the soil and its conservation for use by crops, are of far greater importance than the

question of fertility. Since the problems of dry land agriculture can be better worked out in states more uniformly drouthy, these investigations have been closed with the tenth year.

Since the publication of the last report, Rural School Agriculture Bulletin No. 1, a bound book of 200 pages, containing exercises relating to agriculture and home economics has been published, and a copy presented through the county superintendents to every rural school in the state. This bulletin has been received with high commendations by educators everywhere, and there has been some demand for them by teachers outside the state.

The last legislature appropriated $5,000, which became available August 1st, 1903, for the construction of a building to house the machinery of the experiment station.

DIVISION OF HORTICULTURE.

The work of the Division of Horticulture during the past year has proceeded in much the same lines as for several years previous.

Mr. R. S. Mackintosh, who had been an assistant in this department for seven years, resigned to take the position of Professor of Horticulture in the Alabama Polytechnic Institute, and his place was filled by the appointment of Le Roy Cady.

One bulletin, No. 83, entitled "Apples and Apple Growing in Minnesota," has been published by this division, during the past year. This comprises eighty pages, describes sixty-seven varieties, and contains forty-nine full page illustrations of apples.

The grounds about the new chemical laboratory have been graded, and a new road leading to it laid out.

The crop of apples was unusually large the past year, and about three hundred bushels were harvested. Much interest is now being taken in our seedling apple orchard, which was planted twelve years ago. One hundred twenty-five of these trees fruited this year, and some of them are of much promise.

Work of special interest with seedling wild fruits has been continued.

The raising of hardier apple seedlings has been carried on and about twelve thousand have been grown this year.

The forest garden, which has been planted fourteen years, is full of interesting object lessons to teachers and students of this subject. It is one of the few forest gardens in this country.

The care of the campus has been unusually heavy this year, which has required much attention, owing to the rank growth of grass and the roads being badly washed during the heavy rains. An appropriation should be made for the purpose of paving the gutters and putting our roads in better shape.

The crop of potatoes was considerably lessened by rot, which was especially bad this season.

The sample hedges which were started several years ago make a fine appearance, affording a very interesting object lesson. They will be maintained from now on with very little expense. Our orchards are in good condition and the outlook is very promising for the successful growing of apples in this section, which was thought incredible but a few years ago.

CHEMICAL DIVISION.

Bulletin No. 80 has been issued during the last year by the Division of Agricultural Chemistry, on "Alfalfa, Its Chemical Development, Feeding Value and Digestibility. The Digestibility of Hog Millet."

Bulletin No. 126, "Studies on the Digestibility and Nutritive Value of Bread," has been published by the United States Department of Agriculture, Office of Experiment Stations, Washington, D. C.

A text book of 425 pages, for use in the School of Agriculture, entitled "Chemistry of Plant and Animal Life," has been prepared by Prof. Harry Snyder.

An article by Professor Snyder was read before the International Congress of Applied Chemists at Berlin, entitled "The Testing of Wheat and Flour for Commercial Purposes."

Articles on "Bread and Breadmaking," "Flour" and "Wheat" have been prepared for the forthcoming Encyclopedia Americana, published by the Scientific American Publishing Co.

An illustrated address on the "Nutritive Value of Bread," was delivered before the Millers' National Federation at Detroit.

Other articles, of a more popular nature, dealing with the chemistry of soils and foods, have been published in different periodicals, as Collier's Weekly, Harpers' Weekly, and the Northwestern Miller.

The following bulletins have been prepared and are ready for publication: "The Food Value of Sugar" and "The Digestive Action of Milk, Wheat, Flour and Bread Investigations," including the study of glutinous and starchy wheats, the influence of storage on the keeping qualities of flour, the effect of bleaching of flours, the nutritive value of flour, a study of the composition of the different streams of flour.

During the year the Division of Agricultural Chemistry has moved from the quarters which it has occupied for the past twelve years to the new laboratory which was completed in the fall of 1902. The new quarters provide more adequate facilities for both instruction and analytical work. In planning the laboratory, particular attention was given to construction and equipment, that the work might be carried on with the least expense, having due regard to rapidity and accuracy. A prominent feature of the new building is the laboratory for instruction in farm chemistry.

Prior to the construction of the laboratory, the plans of a number of the more recently constructed chemical laboratories were critically examined. Particular attention has been given to the lighting and ventilation of the building, which is plain but of substantial construction. It is about 60x90 feet, two stories high, with a high basement. The building cost $25,000.

The equipment authorized by the last legislature to cost $5,000, is now being installed.

There have been no changes among the assistants during the past year, and no increase in the working force, although the instruction and other work have materially increased. Among the advanced and special students, some have secured responsible and remunerative positions. Mr. M. A. Grey, a special student, has been placed in charge of the testing laboratory of The Ogilvie Flouring Mill Co. of Montreal, and Miss

Moxness, a post-graduate student, has been appointed laboratory assistant at the Michigan Experiment Station.

Chemical analyses have been made for nearly all of the other divisions of the Experiment Station, as milk, fodders, forage and root crops, paris green, etc. In cases where the chemical analyses have formed a prominent feature of the work, and the conclusions have been based largely upon chemical data, the work has been done on a coöperative basis, each division doing its share of the work and receiving due credit for the work performed, and bearing its portion of the expense. A large amount of free analytical work has been done for the farmers of the state; numerous samples of miscellaneous materials having been received from time to time. This feature of the work of the Division of Agricultural Chemistry has, it is believed, given quite satisfactory results, and has been maintained at comparatively little expense.

DAIRY DIVISION.

In this division systematic records have been kept from the time it was organized of all food stuffs consumed by each animal, the composition of same, the daily yield of milk, butter fat and other solids in the milk, the daily consumption of feed by young stock from time of birth, and weekly gain in growth. In earlier years these data were used in determining the kind of cows that make best return in the dairy, the cost of milk and butter production, the cost of rearing the young and best methods of feeding for the production of stock intended for the dairy. During later years the data have been used in a study of the fundamental principles bearing upon animal nutrition.

Since the publication of bulletin 71, referred to in the last report, a supplementary report has been made in bulletin 79, treating on the "Food of Maintenance, Nutrient Requirements in Milk Production, Protein Requirements and the Influence of the Stage of Lactation on Nutrient Requirements." These subjects are presented by Professor Haecker, under new and improved methods, showing that the standards for food of maintenance and for milk production, in general use, are not reliable guides in feeding practice. In this bulletin new stand-

ards are tentatively formulated, based upon the actual performance of the animals under experiment, giving in detail the amount of each nutrient and total nutriment required by animals in the production of milk of various grades. This is the first work demonstrating that the nutriment required in milk production depends upon the quality of the milk and that the cows should be fed according to the quantity and quality of milk yielded, and not according to the weight of the cow—which has been the basis of the standards in general use. Since economy of production depends upon the knowledge of the needs of the animal for its own use and for milk production, these findings are of great value to the practical feeder.

Experiments in this division are bringing to light the fact that the feed stuffs grown on our western farms come nearer providing the constituents actually needed in milk production than had generally been supposed; that the amount of protein prescribed in the feeding standards is greatly in excess of the amount actually needed, and that by the use of the new standards suggested a marked saving may be made in preparing rations for dairy cows.

Further experiments are being made to determine more definitely the minimum amount of protein with which a normal yield of milk may be obtained and still maintain the cow and her offspring in full vigor.

The experiment referred to in the last report, of rearing dairy bred and cross bred steers, is still in progress and promises satisfactory results. Accurate records are being kept on cost of rearing, gain in weight, comparative value of product; and as soon as definite results are obtained, the matter will be submitted for publication in coöperation with other divisions. The data will also give valuable information bearing upon milk production, which cannot be fully determined by the employment of cows only.

Experiments in calf rearing have been conducted for several years, with gratifying results as to cost and nutriment required through the various stages of growth. This is an exceedingly difficult problem, but from the large number that are still being raised in the dairy herd, calculations can be made which will give the information desired.

In the dairy laboratory daily determinations are made in regard to the per cent. of fat content and solids not fat in the milk from the different cows of the herd, which is now being analzed periodically by the chemical division to show the per cent. of the various constituents in the milk. This gives valuable additional information in regard to the needs of the cow in milk production.

The demand made upon the dairy division for addresses before farmers' meetings is constantly increasing.

The barn accommodations, for the character of the experimental work that is now being done, are inadequate. Cows that are subjected to fixed rations for a series of winters in trials of returns made for digestible matter consumed should have quiet, comfortable quarters, thoroughly lighted and ventilated. They should be kept separate from the members of the herd not employed in nutrition investigation, and should not be used in connection with class work in the study of the breeds and in live stock judging; because if used in connection with class work abnormal shrinkage in milk takes place and the value of the experiment is lessened if not wholly destroyed.

Calf rearing is an industry that is constantly demanding more attention, and heavy losses are sustained every year for want of comfortable, well lighted and ventilated quarters. Many of our prominent experiment stations have built separate barns for the dairy herds, provided with ample stall rooms, judging and lecture rooms, milk rooms and quarters for the stock foreman, feeders and milkers.

VETERINARY DIVISION.

During the past year the health of our farm stock has been as good as usual. There have been a few losses from various causes. Among these I must report a continuance of hæmorrhagic septicæmia, and a few cases of tuberculosis. The cases of hæmorrhagic septicæmia have been confined to young calves of from four to six weeks of age, the infection evidently having lost so much in virulence, that the older cattle have been able to resist it. Our herds have been tested for tuberculosis twice,

spring and fall, a few cases appearing at each test. Most of those reacting during last fall, were of animals that had previously reacted and had been isolated. There has been one outbreak of hog cholera, which was promptly checked by isolation, disinfection and the use of our contagious ward stalls in the veterinary hospital. Infectious abortion has also continued to a rather limited extent in the dairy herd. It seems very difficult to get rid of this infection when once it has obtained foothold. Two cases of lumpy jaw appeared in our herd during the past year, but no serious trouble is anticipated.

About 200 lantern slides have been prepared for class demonstration work, and the museum has been developed, until it has become quite an important teaching feature.

Publications.—Dr. Reynolds has published a text book, "Veterinary Studies," for use in the veterinary classes of the farm school, and the short course work. This book has been very well received by agricultural colleges and agricultural college students, twenty-two agricultural colleges having already adopted it as a text book, or signified their intention of doing so.

Bulletin No. 82, on Hæmorrhagic Septicæmia, containing about 30 pages, was published from this department, and was very favorably received by the agricultural public, by the veterinary profession, and the agricultural papers. The investigations and other work reported in this bulletin deal with the practical features of this serious disease. This bulletin discusses the practical bearing of the disease upon the live stock interests of Minnesota, and shows that it is a very serious problem. The peculiar feature in connection with the cause of the disease, is that the rod-shaped germ which is now recognized as the specific cause is apparently identical with the swine plague bacillus, and very similar to the chicken cholera germ. The history and development of cases are given at considerable length from actual field observations. The veterinarian had opportunity to study quite a number of cases throughout their entire course, and has put these data on record in Bulletin No. 82.

Attention is drawn especially to the fact, that ante-mortem symptoms are as a rule unsatisfactory, the acute cases dying

very suddenly. Symptoms by which stockmen may recognize the disease, especially on examination post-mortem, are given quite fully; also statistics concerning the extent of the spread of this disease in Minnesota and estimated losses. An outbreak of the disease which appeared on the University Experimental Farm was quite serious, on account of its financial loss, but it gave us almost ideal opportunities for studying the disease. Attention is drawn to the fact that certain cases of hæmorrhagic septicæmia very closely resemble cases of milk fever, and may be easily mistaken for such in cases of disease developed within a few days after calving.

A carefully prepared table is presented, which offers a very complete comparative study of hæmorrhagic septicæmia, anthrax, symptomatic anthrax and infectious cerebro-spinal meningitis. This was deemed important, because these diseases were very easily confused by stock men, and often in obscure cases by veterinarians. The diagnosis is especially important for anthrax, symptomatic anthrax and black-leg.

Proposed Station Work.—Quite extensive plans are under way for the station work in this division during the coming year. One series of proposed experiments deals with a practical study of ventilation problems from a physiology standpoint. Another series of experiments has been outlined with a view of determining the relative desirablity of various methods of disinfecting large stables, the following points to be especially considered: Rapidity, expense, difficulties or technicalities involved and efficiency. A pasture experiment with tuberculosis has been under way, since the early spring of 1903. The purpose of this experiment is to determine approximately the risk of outdoor infection, when tuberculous and non-tuberculous cattle are pastured together. This experiment involves two phases, the first an actual field trial by pasturing some tuberculous cows with two yearling steers that were not tuberculous. The second proposes to spread cultures of bovine tubercle bacilli over a small plot of grass and then keep record of climatic conditions, determine how long the grass remains infectious to laboratory animals, and possibly later to cattle.

DIVISION OF ANIMAL HUSBANDRY.

The policy established a year ago, of requiring daily reports, has proved to be a valuable method of regulating the work of this division and will be continued. The feed records of individual beef animals and of litters of pigs kept during the last year, have furnished much information on the cost of production, and will be further perfected and extended until the record of every animal grown on the farm is obtained in detail.

The beef herd has been built up by the purchase of a few breeding animals, and a few pure bred calves have been raised, though an outbreak of hæmorrhagic septicæmia last spring caused the death of a number of calves. The flock of sheep has been strengthened by the purchase of typical specimens of the breeds not represented heretofore, and a number of home bred sheep have been considered good enough to keep for breeding purposes.

The new piggery has proven well adapted to the growth of young pigs, and has enabled us to raise a large number of pigs with very little loss from disease.

Sales of stock have been good throughout the year, and farmers obtaining it have expressed themselves as well pleased with the quality of the animals obtained. The sales for the year exceed the purchases by $393.98. There is also an increase in value of the live stock inventory of $2,095.00, making a total increase in the value of the live stock of $2,488.98.

The experiments in forage crops for sheep and swine have been continued through the year. Only mature sheep were used for pasture work, as it was believed that more reliable data could thus be secured. A number of plots of tame grass have been seeded for comparison with annual crops—as sheep pasture—and the fields have been partly re-fenced with a view to furnishing more economical methods of pasturage. The yards adjoining the piggery have encroached somewhat upon the land formerly used for producing winter forage, and small fields for swine pasture have farther reduced the land avail-

able for sheep foods. The health of the herds and flocks has made necessary the change, and it is not believed that the work done will be any less efficient than in the past. More attention will be given in the future to soiling and pasture crops for swine, and to discovering crops suited to short rotations for hog food.

The steer feeding experiment in progress a year ago was completed in June, and the figures are at hand for compilation, The results show great variation in the capacity of different individuals to make use of the food consumed and in the economy of production. Measurements and photographs have been carefully preserved for illustrative purposes.

More steers have been purchased for the purpose of continuing the study of the influence of individuality on cost of growth, and the records of several home bred calves are being carefully kept for the same purpose.

No extensive experiments have been undertaken with sheep except in forage work. Digestion tests of macaroni wheat and alfalfa have been made in coöperation with the chemical division and minor tests of speltz, corn, barley and oats as sheep foods have been completed.

The experiments with pigs have been confined to cross-breeding and to recording the growth of litters of pigs of the various breeds. As far as possible each litter has been kept intact and fed liberally. When finished the plan is to slaughter the whole litter and observe the variation in growth made and in the quality of meat. Pigs of the cross-bred parentage were again sent to the International Exposition, where they compared favorably with other breeds, getting 2nd and 3rd prizes in their class.

As soon as funds can be had for the purpose, coöperative work should be started with men who are feeding stock, for the purpose of securing data on the methods employed, and the feeds used and to enable us to suggest more economical feeding of farm stock. Statistics should be secured of cost of production on farms, and comparative feeding tests made under various farm conditions. A man who is familiar with all phases of stock feeding, could well be employed by the station for this purpose.

DIVISION OF ENTOMOLOGY.

The entomologist was called to Ottertail County in June, 1902, on account of an outbreak of grasshoppers, the county commissioners urging that he come at once to do what he could to remedy the evil. He found stubble fields filled with thousands of the lesser migratory or White Mountain locusts (*M. atlanis*). For the most part they were well along past the fourth moult, although some were found considerably younger. It is to be noted that these grasshoppers hatched in the old stubble. The most threatened area in this vicinity was a tract of unplowed stubble containing 240 acres, owned largely by non-residents who will not plow. Some farmers were plowing thoroughly, but all were very much alarmed at the near presence of such a large tract of unplowed land. The situation was so serious that, upon consultation with the governor of the state and director of the station, it was determined to plow this tract at the expense of the state, and thus not only avert immediate loss but also reduce, if posible, the number of grasshoppers that would otherwise be on hand to do damage next year. Accordingly the most threatened tracts, about 200 acres, were plowed, and it is believed that the result was satisfactory, for since that time no complaint has come from that part of the county because of grasshoppers.

On June 26 the entomologist was summoned to Gentilly, a town in Pope County, about ten miles from Crookston, where the same variety of locust was found, causing injury upon all well drained sandy ridges. On one farm it was found that the wheat next the old stubble, and beans, barley, and young flax, were eaten clean.

From Gentilly the entomologist went to the Hill River district, near Lindsay postoffice east of Crookston, at the request of the county commissioners, where by far the most serious conditions found in the state prevailed. Flax, grass, wheat, barley and oats were found mowed down by the grasshoppers. At the date of his visit, June 26th, the farmers were complaining bitterly of a 300-acre piece of stubble, which had been allowed to lie fallow for two years or more. Here the grasshoppers were working toward the south.

In all about twelve hundred gallons of oil were distributed free of cost, through the county commisioners, to help the farmers combat the pest. This oil was judiciously used, but as the insects were so numerous the loss to the farmers was severe, although bushels of the grasshoppers were killed. With these two exceptions, and a slight outbreak near Twin Valley, and an early and limited attack near Glyndon, in Clay County, grasshoppers caused no loss in the state, so far as is known.

In July another trip was made to the Hill River district, where hoppers were found by the thousands, feeding upon the wheat heads. The last trip to this region was made in September, when consultations were held with the farmers as to the best means of proceeding the following year. Almost all united in the expression of a desire for some law which would compel the plowing of stubble land infested with eggs.

Complaints of chinch bugs began to arrive at the station in July and during the summer Stearns, Isanti, Chisago, Dakota, Sherburne, Meeker, Kennebec, Lyon, Anoka, Hennepin, Wright and Waseca counties suffered from this persistent pest. Stearns, Isanti and Meeker were the worst sufferers. These counties were visited and the farmers shown the best means of preventing the chinch bug from entering the corn, and given what help was possible under existing conditions. Demonstrations were resorted to in explanation of the dust furrow and tar line, and farmers were urged to kill as many of the bugs as possible, while they were migrating from the wheat to the corn, thus lessening the crop of bugs for the following year.

The Hessian Fly has spread over the entire wheat raising area of our state. It well deserves to head the list of injurious insects in 1902. The following counties were affected: Ottertail, Kennebec, Pope, Clay, Becker, Douglas, Meeker, Marshall, Rock, Isanti, Lyon and Morrison. Many infested farms were visited and it was found that the loss from this pest reached all the way from a fraction of one per cent to as high as fifty per cent. in a few localities. Many farmers not familiar with the Hessian Fly and its work ascribed the fallen wheat heads to the work of the chinch bug or of hail. The

"flax seed" stage of the insect on the wheat plants was shown to the farmers so that they might easily recognize this pest. The life history of the insect was given in brief talks, and the importance of coöperation in plowing the stubble in the fall was urged as being the most effective way of keeping the pest in check. The value of rotation of crops was also dwelt upon.

Besides the work mentioned above, experiments have been conducted as to the best methods of combating the horn fly of cattle and the white grub which infests lawns.

In May a trip was made into the lumber sections of Lake County to study and collect insects affecting our timber interests.

Many nurseries throughout the state have been inspected during the year and have been found fairly free from insect pests and fungous diseases.

POULTRY DIVISION.

The work for the past year in this division, has been mainly a study of best conditions and management of farm flocks. The problem of winter egg production is receiving especial attention. Experiments with natural and artificial incubation have been continued. Owing to lack of room, two breeds only are kept—Plymouth Rocks for general purpose fowls and White Leghorns for layers.

As was mentioned in the last report, it is still thought that a number of small houses, each to illustrate a different method of building a farm poultry house, would be a valuable object lesson and would help to relieve the crowded condition of the poultry quarters.

NORTHWEST EXPERIMENT FARM.

On this farm the experimental work which was being carried on in much the same lines as formerly, was seriously interfered with by a hail storm on July 15th, 1902, which destroyed the standing crops and rendered nearly valueless the work in the trial plots. After the storm the most of the grain was cut for hay.

During the year a barn to accommodate fifty head of stock, containing a root room, silo and feed grinding room was begun; also an incubator house and about seven miles of woven wire fence built. Pipes for supplying water to the different buildings were also laid.

A large field has been seeded to grass, using those varieties which have given promise of usefulness in the trial plots of former years. This is to be a part of a study of the rotation of crops best adapted to this section of the state.

A herd of Galloway cattle has been purchased and other pure bred cattle are being secured as opportunities offer. Specialists have been placed in charge of the live stock and poultry.

In trying to solve the question of fruit for the Red River Valley, the work is confined mostly to seedlings. Several thousand apple, plum and other seedling trees are now growing on the grounds.

The superintendent has devoted considerable time to institute work and to aiding in the organization of creameries and cheese factories in the Red River Valley.

NORTHEAST EXPERIMENT FARM.

The equipment of the Northeast Experiment Farm in buildings and machinery is now fairly complete. The farm house is sufficiently large to accommodate the hired help, kitchen help and superintendent. It would not make a suitable dwelling for the superintendent if he were married, as its capacity is only equal to present conditions. Up to this year the house has been poorly heated by stoves. A wood-burning, brick furnace has now been put in, and a drain and a bathroom, greatly improving the comfort and sanitary conditions, especially during the winter. The house contains four bedrooms on the second floor, and two on the first, with office, sitting and dining rooms, and kitchen. There is also a good cellar. A wagon shed was built in 1902, 16x40 feet. The buildings now consist of a dairy barn 30x58 feet, horse barn with two sheds for machinery, wagon shed, sheep pen, hog

pen, stone root cellar, hot house, blacksmith shop, ice house, stone milk house and well, with water to all the buildings.

There are 2,276 rods of fencing on the farm, and the amount of land under cultivation in 1903 is 112¾ acres, of which 60½ acres were cleared when the farm was acquired and 52¼ acres since the state has managed it. In 1903, about four acres additional was stumped and planted to potatoes. The system of hog pastures was completed and fenced with woven wire. This, with the sheep pasture lots, gives a complete rotation of pastures for hogs and sheep.

Field experiments are giving more and more useful results each year. The twenty-four permanent rotation plots, which illustrate the effect upon the soil of as many different plans of cropping, both good and poor, are beginning to show effects in yields, which will become more and more pronounced from now on. The station is doing a valuable work with potatoes, of which nearly one hundred varieties were tested in 1903, both for yield and quality. Strains of the same variety from different sources were also planted, and showed great difference in yield. An original method by Herman H. Chapman, of correction of the yields of potato plots, so as to eliminate the difference caused by varying soil conditions among the plots was followed with good results. The new variety test of oats for the selection of a new kind for distribution is in its third year. Oats are by far the most important grain crop, and yield is the chief point considered. Variety tests of clovers and grasses for meadow and pasture, and tests of the absolute and relative amount of timothy and clover seed to sow, gave instructive results.

A new experiment in changing seed oats from one locality to another is in its second year, and is planned in such a way as to secure accurate and effectual knowledge on this subject.

Fodder for stock feeding again demonstrated its usefulness, and the test made as to time of sowing, kinds, amounts and methods of sowing, clearly indicated the proper course to pursue for this locality. Corn for ears did not ripen.

Many other but less important lines of experiment work were conducted, as tests of wheat and barley, millet, peas and beans, and garden vegetables. Small fruits were uniformly

successful, and progress was made in determining the best kinds to recommend for planting. Native plums again gave a good crop from orchard trees set in 1899. Apples have not succeeded, due to poor location of orchard in sandy sub-soil as well as severity of winters. The hedges of ornamental shrubs are doing well.

The flock of grade Oxford sheep are now being bred to a Shropshire buck, and continue to give valuable illustrations of their proper use in clearing land.

The herd of cattle bred to a red polled bull is in good condition, and the dairy work is now capable of very satisfactory development.

The ten acre plantation of young white and Norway pine set at intervals of 4, 6 and 10 feet, on cut over land in 1900, is thriving, and will soon be one of the most interesting features of the Experiment Farm.

In the winter of 1902-1903, a bulletin containing 69 pages, No. 81 of the Experiment Station, was published and distributed throughout Northeastern Minnesota. This bulletin contains a full review and summary of the work of the Northeast Farm since it was established.

BULLETINS.

The bulletins are sent free to about seventeen thousand subscribers. Requests from out of the state for our bulletins are increasing rapidly. Many of our files, especially those on special subjects, are exhausted. Readers of our bulletins are showing their appreciation more each year by thousands of personal letters received here during the year relative to our school and experiment station work.

Six bulletins, comprising 280 pages, with many illustrations, have been issued during the year, as well as one press bulletin, "The Criddle Mixture," and one class bulletin, "Growing Field Peas for Seed." Bulletins are issued for gratuitous distribution to the citizens of Minnesota who apply for them.

Respectfully submitted,

WM. M. LIGGETT.

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INSECTS NOTABLY INJURIOUS IN 1902.

F. L. WASHBURN.

THE HESSIAN FLY.

Cecidomyia destructor, Say.

This pest well deserves to head the list as I found it alarmingly abundant over the southern, southwestern and the entire western part of Minnesota. Complaints began to come in about Aug. 5, and from that time on increased in numbers until after Aug. 11, when every mail brought letters relative to this insect. It has been a very favorable year for the fly, an abundance of moisture being highly favorable for its development. The result of its attacks appears most serious where grain is on sandy soil, evidently because, on account of thinner growth, the stalks fall more easily, while on richer soils the ranker growth helps to keep up the weaker plants.

Reports of injury have come from Perham, Mora, Fergus Falls, Little Falls, Crookston, Moorhead, Lake Park, Hawley, Pelican, McIntosh, Alexandria, Beltrami, Litchfield, Maine, Warren, Luverne, Cambridge, Kensington, Stodt, Oswell, Forest City, Glyndon, Gentilly, Liberty, Lynd and Garfield; representing the following counties: Otter Tail, Kennebec, Polk, Clay, Becker, Douglas, Meeker, Marshall, Rock, Isanti, Lyon and Morrison. Personal investigation upon the farms of G. E. Pratt near McIntosh, Eli Benoit near Gentilly, E. J. Grover near Glyndon and Mr. North and G. S. Barnes in Clay county; James Hanna, Forest City, E. J. Scott near Fergus, E. S. Wemple and Eli Dewey same place; Mr. Gruett, Clay county, Henry Bausman, Fergus, A. J. Letson, Philip Rutter, L. Bartlett, A. J. Thompson, J. M. Whighton, George Renzell and W. H. Mitchell all near Alexandria, revealed the fact that loss from this pest ranged from a fraction of one per cent to as high as fifty per cent in a few localities or parts of farms, and Mr. Keefe of Maine stated that his wheat

crop only averaged sixteen to seventeen bushel per acre owing to the Hessian Fly. Mr. G. E. Pratt states that in 1896 he lost almost his entire crop on account of this pest.

In order to give a general idea of the loss caused by this insect I counted upon one field not badly infested, twenty straws down as a result of Hessian Fly injury, in one square yard. In this case the straws standing on the same square yard representing the yield were not counted; but upon another field only slightly injured I obtained a full count, and upon one square yard 423 upright straws were counted, that is, so many heads were harvested. In this area 20 straws were down from other causes than the Hessian Fly injury and 6 straws were picked up containing "flax seeds." This puts the loss in that square yard between one and two per cent which is hardly appreciable. It is true this field was but slightly affected and other portions may have given a much greater count, the North farm for instance, (see Fig. 1) where over fifty per cent of the wheat was down at the time of my visit. To give a further idea of the havoc this pest can cause, I quote from the report by C. L. Marlatt of the U. S. Dept. of Agriculture, in which he states that the loss in the Ohio Valley upon the winter wheat of 1899-1900 amounted to from thirty-five to forty million dollars. The minimum annual damage due to Hessian Fly is estimated at about ten per cent of the product in the chief wheat growing sections of this country, which indicates an annual loss of forty million bushels.

The worst field visited was on the North farm near Glyndon above referred to, where quite fifty per cent of the wheat crop was lost. I believe an average loss of eight per cent for all counties in this state where wheat is raised to be a conservative estimate for this year. The grain has not been universally attacked over the portions mentioned above but, as indicated, almost every locality has suffered a little and some individual fields excessively. The Red River Valley is particularly afflicted and all along the line of the Great Northern Railroad from Alexandria to Moorhead and beyond, fallen wheat could be seen from the train and in such abundance as to indicate great numbers of this pest.

In 1901 the first report of injury came from Otter Tail county where a local miller placed the loss at fifty per cent. It was also reported from St. Peter, St. James, Worthington, Pipestone, Mar-

shall, Willmar, Wadena and Beaver Falls in 1895 and 1896 when the flies were abundant, the loss on the entire crop being estimated at from five to ten per cent and in individual cases as high as twenty-five per cent. Mr. Forbes reports it present conspicuously

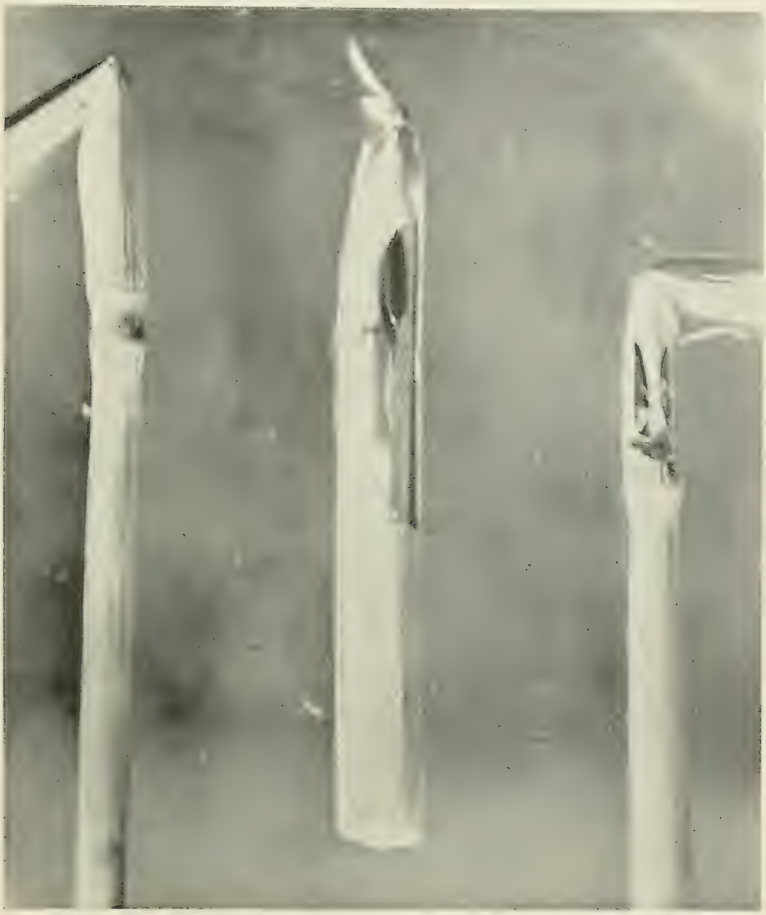


Fig. 2.—Three straws showing work of the Hessian Fly; "flaxseeds" exposed in two straws on right. Original.

in 1897 and 1898, which is evidence that it is on the increase in the state and that it calls for radical remedial or preventive measures. It is all the more insidious as a foe to our farmers from the

fact that its presence is not revealed to them until the injury has been done and the grain is down, and from the further fact that a large number of our farmers are unfamiliar with its work and have been accounting for the falling grain as the result of hail. In fact, I am creditably informed that some sought and obtained hail insurance for grain injured by the Hessian Fly. It is well worth noting that although it is generally on the increase and bids fair to cause much greater injury in the future, its increase like that of many another pest is marked by periods of decrease. It is wave-like, if I may use that expression, for as its numbers expand favorable conditions are created for parasites which infest it, causing them to increase in enormous numbers and temporarily get the upper hand. But their victory is necessarily of short duration and only leads to their own destruction for as they destroy their food supply their own numbers decrease, and again their host, the Hessian Fly, takes another bound forward, for the time at least not much hampered by parasites. Although the parasites of the Hessian Fly are largely common in all localities of the state where the fly is found, the writer having noted their presence in many specimens secured from different points, the farmer cannot afford to neglect certain preventive measures which lie ready at hand in keeping down the pest which bids fair to very materially reduce our output of wheat. In mentioning these measures I wish as a preliminary to state that the individual farmer must use his judgment in their application. He should be guided by the peculiar conditions of his surroundings, conditions which might not occur in the case of another farmer.

1. Burn the stubble when possible. This is particularly desirable when, from any reason, shallow plowing is unavoidable. If the stubble is left long it will burn easier. Some farmers are willing to go to the trouble of spreading straw from threshing over the stubble, thus insuring the burning and at the same time getting rid of some "flax seeds" which may have lodged on the surface of the straw pile at the time of threshing.

2. Fall plowing of the stubble in such a way that the straw is completely turned under.

3. All screenings and litter about the threshing machine should be cleaned up and either fed immediately or burned, leaving no

litter from the threshing on the field. There is no absolute need of burning the straw pile. The flies emerging from "flax seeds" in the center of the pile will never reach the surface.

4. Since the fly lays its eggs as a rule near the locality where it emerges from the "flax seed" it is best not to plant wheat on the same ground two years in succession where rotation is possible. Varieties of wheat that produce a stout stalk are the least affected by this pest.

5. Co-operation is absolutely necessary, for, however careful one

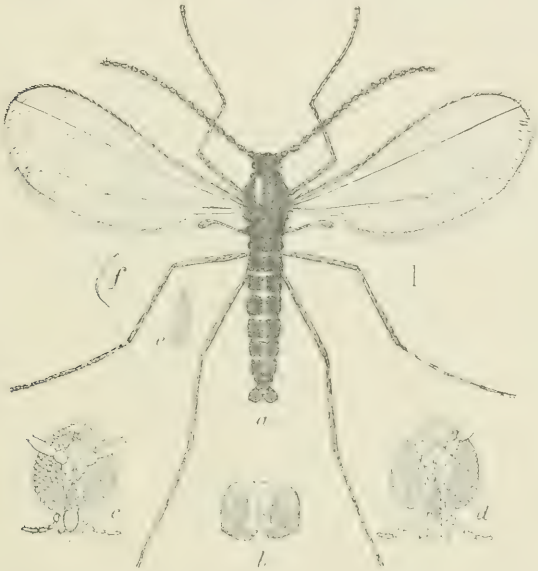


Fig. 3.—*Cecidomyia destructor* (Hessian fly): (a) male; (b) enlarged anal segment; (c) head of female; (d) head of male; (e) scale from leg of male; (f) scale from wing; all greatly enlarged. C. L. Marlatt, U. S. Dept. of Agr. Div. of Entomology.

man may be, if his neighbor is not equally so the latter's fields will afford a supply of this pest for the former. Since this pest issues from the "flax seed" early in May, a stubble field left for corn land and not plowed up to the 10th of May or later has probably discharged its quota of flies ready for mischief before plowing.

APPEARANCE AND LIFE HISTORY OF THE HESSIAN FLY.

The fly is dark colored, much smaller than an average sized mosquito which it somewhat resembles. Each female lays on an average over 200 eggs (generally early in May in this latitude) on the upper surface, usually, of the leaves of the wheat. It is known to also infest to a slight extent barley and rye but I have found its presence hardly appreciable in barley in Minnesota. The eggs are reddish, very small and hatch in about four days, the maggots crawling down the leaf until they get between the leaf and stalk where they feed upon the latter. After a few weeks

Fig. 4.—Female of *Merisus destructor* Say. Enlarged. Lugger.

each maggot changes into the so-called "flax seed." In this stage, in Minnesota, the insect passes the winter and emerges as a fly in the spring. To the best of our knowledge there is but one brood in this state though this question is a problem the entomologist has promised himself to endeavor to solve next season.* Excessive dryness and heat during the "flax seed" stage is highly injurious, the development being aided by dampness, this pest thus radically differing from the Chinch Bug.

At least seven parasites are found in America affecting this pest; about as many in Russia and ten are quoted in England. The principal parasite is a minute four winged fly *Merisus de-*

*Since writing the above I have been creditably informed that "flax seeds" were found in abundance on wheat five inches high in the latter part of last June on the farm of C. Johnson, near Warren, Marshall county.

structor, Say. (see fig. 4), which so far as we know lays its eggs upon the young larva of the Hessian Fly and emerges a full grown insect from the so-called "flax seed." Minute holes in the sheath at joints infested by the Hessian Fly show where this parasite has emerged, but unfortunately a minute secondary parasite (a species of *Tetrastichus*) reduces the numbers of our little friend *Merisus.*

In a breeding jar kept under natural conditions one species

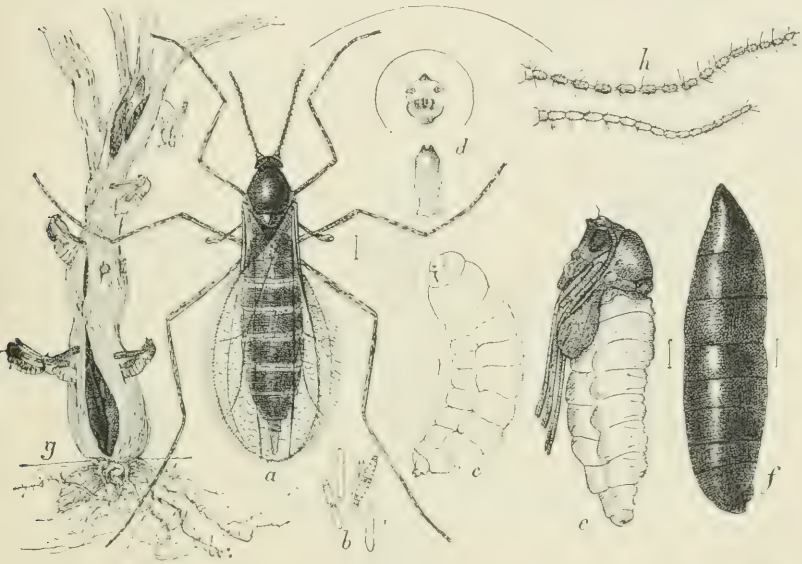


Fig. 5.—*Cecidomyia destructor* (Hessian fly); (a) female fly; (b) flaxseed pupa; (c) larva; (d) head and breast bone of same; (e) puparium; (f) cocoon; (g) infested wheat stem showing emergence of pupae and adults.
C. L. Marlatt, U. S. Dept. of Agr., Div. of Entomology.

of *Merisus* emerged from "flax seeds" in straw Aug. 15th, and more later.

See also Fig. 57 on page 67 at end of this report.

THE CHINCH BUG.

Blissus leucopterus, Say.

In view of all the previous publications from this office relative to this pest, which well deserves second place in the year's list of injurious insects, it is surprising that the entomologist should

have been called upon so often this season to demonstrate the simple and effective means of preventing injury to corn and in some cases to describe such a generally well known insect.

It has been reported this season from Belgrade, St. Augusta, Luxemburg, Carmody, Kimball, Wyoming, Hedrum, Haven Prairie, Big Lake, Forest City, Litchfield, Cambridge, St. Francis, Osseo, Anoka, Farmington, Cedar Mills, Elk River, Mora, Bradford and Lynd, representing the following counties: Stearns, Isanti, Chisago, Dakota, Sherburne, Meeker, Kennebec, Lyon, Anoka, Hennepin, Wright and Waseca. The majority of complaints came from the counties of Stearns, Isanti and Meeker in

Fig. 6.—Chinch bug (*Blissus leucopterus*) adults of short-winged form—much enlarged (adapted from Webster): C. L. Marlatt, U. S. Dept. of Agr., Div. of Entomology.

the order given. A line starting at Mora and running southwest to Benson and then south to the Iowa boundary would appear to mark the northern and western limit of affected localities in this state. I have not this season (barring an unsubstantiated rumor that a few occurred in the sandy portions of Douglas county) been able to detect it north or west of the above mentioned line, though doubtless there were many affected localities from which I did not hear.

Consulting the late Dr. Lugger's reports of '95 and '96 I note that he claims that in 1887, besides many other places, they also occurred in Pine, Crow Wing, Hubbard, Wadena, Todd, Morrison and in '95 and '96 in Morrison, Otter Tail and Douglas counties lying to the west or north of the boundary I have indicated. In 1895 also it is given as "reported" at Vermilion Lake.

In a map contained in Farmers' Bulletin No. 132 U. S. Dept. of Agriculture on page 8, we are startled to see it is given as occurring over the entire state of Minnesota, but as this is really

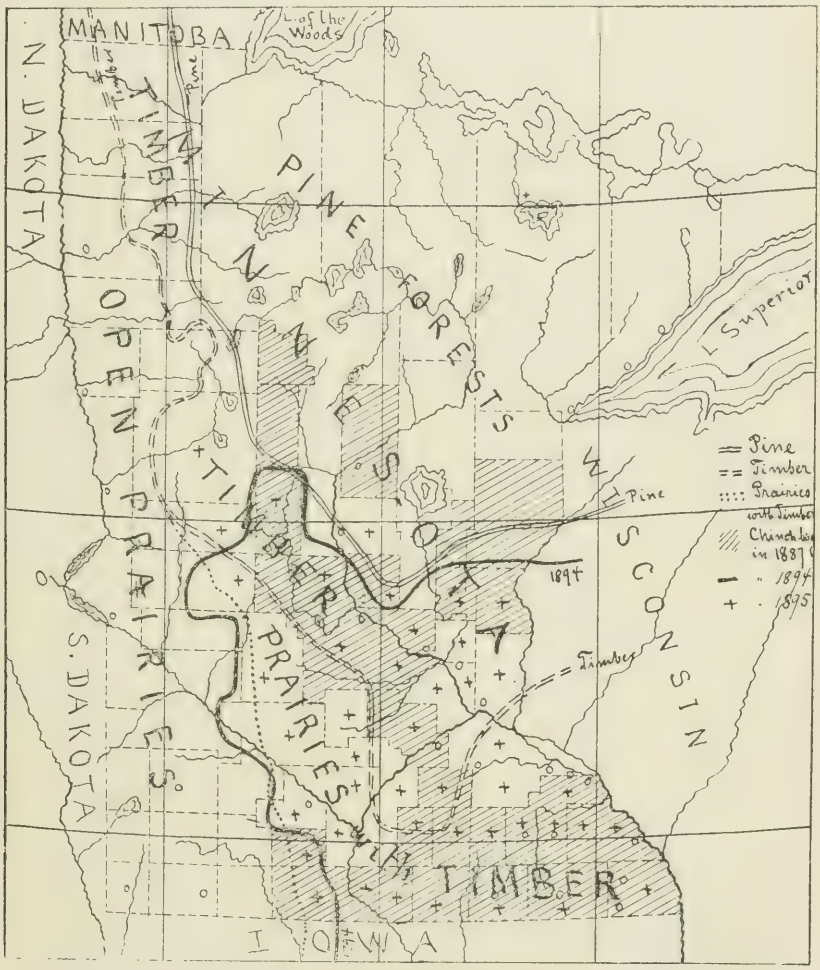


Fig. 7.—Map of Minnesota, showing distribution of chinch bugs in 1887, 1894, and 1895. Also the distribution of pine forests, of deciduous trees, of prairies with timber, and open prairies. Lugger.

a map indicating its range over the United States it is probably intended to convey in a general way its occurrence over a large part of this state and must not be taken too literally. It certainly

seems to be very scarce or lacking along our entire western border from south to north. I looked for it carefully in the counties of Clay, Otter Tail, Douglas, Polk and Itasca and found no trace of it, and met with the statement everywhere in these counties (with the exception of the rumor mentioned above in Douglas) that it was not known to occur. It will be seen then from observations made by both Dr. Lugger and the writer that it is a pest of southern distribution in this state and it is further to be noted that it is found more conspicuously in that part of the state which has become more or less wooded; in other words, in localities where farms are interspersed with woodland affording better chances for hibernation and less likelihood of destruction through burning. Years ago, it seems, this rolling country which is now fairly wooded, was subject to annual burnings. These have ceased allowing the growth of timber and at the same time the increase of this pest.

The Chinch Bug, a native of this country and first living upon wild grasses before grains were placed before it, probably causes greater loss than any other one pest. To give some idea of the extensive injury to be laid at the door of such an insignificant looking insect, hardly more than an eighth of an inch long, we quote from a government report recently issued, "the loss for single States in one season have been estimated at from ten to twenty millions of dollars; that for single years throughout its range at above one hundred million dollars. Large as these figures are, when the actual estimate of shrinkage in the yield of wheat and other grains, not to mention forage crops is made, it will be seen that they are reasonable and probably within the true amount."

In 1871 Illinois is said to have lost $10,000,000, while that State with Iowa, Missouri, Kansas, Nebraska, Wisconsin and Indiana in 1871 lost $30,000,000. In 1874 the loss of above seven States was estimated at $60,000,000. Missouri alone losing $19,000,000. In 1887 Minnesota alone lost over $6,000,000 in the counties affected.

ITS APPEARANCE AND LIFE HISTORY.

The Chinch Bug has been so frequently described that it hardly seems necessary to go into details and we will merely give

Fig. 8.—Different stages of the chinch bug (*Blissus leucopterus*) enlarged and natural size; (a) egg; (b, c, d, e) young stages; (f) adult. Lugger.

a brief description which with the pictures should be sufficient for those not acquainted with it.

The full grown insect is about ⅛ of an inch long; black with whitish wing covers; a prominent black spot marks the outer edge of each wing cover (a casual observer would call these wings) at about the center. There is, too, a form with short wings and individuals are found between these two extremes, that is with wings of various lengths. The female lays her whitish eggs, one individual depositing nearly 500, but not all in one batch, at base of plant, for the main part on the roots. From two to four weeks are occupied in egg laying. The eggs hatch in about two weeks but may hatch sooner and may take longer. The young larva is reddish and extremely active. As it grows it becomes darker colored and more like adult. In about two months it becomes full grown like its parent. During this two months it is sucking the vitality of wheat, barley, if there is any in its neighborhood, and swarming on the roots of pigeon grass and millet if it is fortunate enough to find it. Oats do not meet with favor unless there is lack of other feed. Millet appears to be its preference, a fact which will be further commented upon later, and even if on the corn it will leave that succulent plant to gather by the thousands about a piece of pigeon grass.

It loves warm sunshine, and cold and wet are disastrous, which latter fact may account for the comparative scarcity of the pest in our State this year, and for the fact that sandy soil where the wheat does not grow rankly and thus allows the sun to reach the soil at its base is worst affected. When the grain is cut or before if it becomes destitute of sap, old, half grown and young Chinch Bugs migrate to the nearest crop which is still succulent. This is generally corn and thousands can be seen migrating to new pastures. It is a curious fact, that, although many are winged at this time they do not fly but for the most part travel over the dusty soil with their less fortunate companions. If they are already in the corn and this has matured they will leave the corn as they do the wheat. This migratory horde will sometimes penetrate to the 15th or 20th row in the corn field and even further, the outer rows appearing frequently almost black with the pest.

Soon after the middle of September the generations raised during the summer begin to seek winter quarters which may be

at some distance from the crop last attacked by them and to be reached only by flight. Places chosen for hibernating are corn shocks left in the field, rubbish and litter of all kinds, fallen leaves in the neighboring timber and Marlatt claims that they can be found by the thousands in the soil at the base of stools of wild grasses where these have not been destroyed by cultivation; he cites it as probably the ancient habit of the species before cultivated crops were in existence. The spring finds them flying from their places of hibernation to cultivated fields. Early in May in this latitude but earlier south of us. At this time they are everywhere; one finds them on his clothing in walking or riding and all in-

Fig. 9.—Chinch bug (*Blissus leucopterus*), adult of long-winged form, much enlarged (from Webster). U. S. Dept. of Agr., Div. of Entomology.

stinctively seeking the crop which will afford their young sufficient nourishment during their development. This crop is almost universally wheat, and while in the wheat from the very nature of the case they cannot, with our present knowledge, be successfully dealt with. From the fact that they fly at this time there can be no really effectual barrier to prevent their entering the wheat field. I intend to try planting millet next season, experimentally, in a strip, say six feet wide about the wheat field, at the same time that the wheat is sown, and some strips at intervals through the field. Since they are very fond of millet this may be effective as a trap crop and as the bugs would stay on it as long as any sap ran it could be cut just before maturing and burned with the insects before it was quite dry. Not having tried this I cannot speak authoritatively upon its effectiveness. Plant-

ing millet at the same date as wheat may endanger the seed in some soils, but farmers have told me this season that they have raised millet planted that early. Some workers have suggested planting millet between the wheat and corn or about the corn field thus protecting the latter crop. This pest has but few enemies and given favorable climatic conditions increase almost without natural check. A predatory bug is said to prey upon it and among the birds it is claimed that meadow larks and black birds have a fondness for it in spite of its peculiar "bedbuggy" odor so disgusting to man, and the stomach of a single quail examined in Nebraska was found to contain over 500 specimens of this pest all eaten in one day.

OUR EXPERIMENTS AT THE STATION.

On May 28th the Agricultural Department of the Station complained to the Entomologist that the bugs were then threatening to seriously injure some experimental plats in the nursery. I found them then copulating and egg laying, which lasted as late as June 2nd. The wheat was young and the question arose as to how the plats were to be saved. On May 31st, millet was planted around and between the plats. Carbon bisulphide was used June 2nd, canvas covered frames having been made to cover portions of the plats, and we having first tested it on other wheat; the idea being that if we could by several applications kill off the bugs at that time on the wheat the young millet would attract other bugs which might be seeking food from the outside. The treatment was only partially successful and its use was abandoned. The reader will understand of course, that the methods adopted here were practicable only when used on a small scale and could not be applied on large fields. It was then decided to use kerosene emulsion. We had found that one part emulsion to ten parts of water did not injure wheat upon which it was first tried. On June 21st and later the emulsion was used on the experimental plats at the strength of one part to ten parts of water and an examination was made June 30th to note its effects. While some of the leaves around the roots appeared a little burned, on the whole the grain looked very well. A goodly proportion of the bugs were killed by this treatment. Upon July 23rd the emulsion was again applied but to the outside rows only. On July

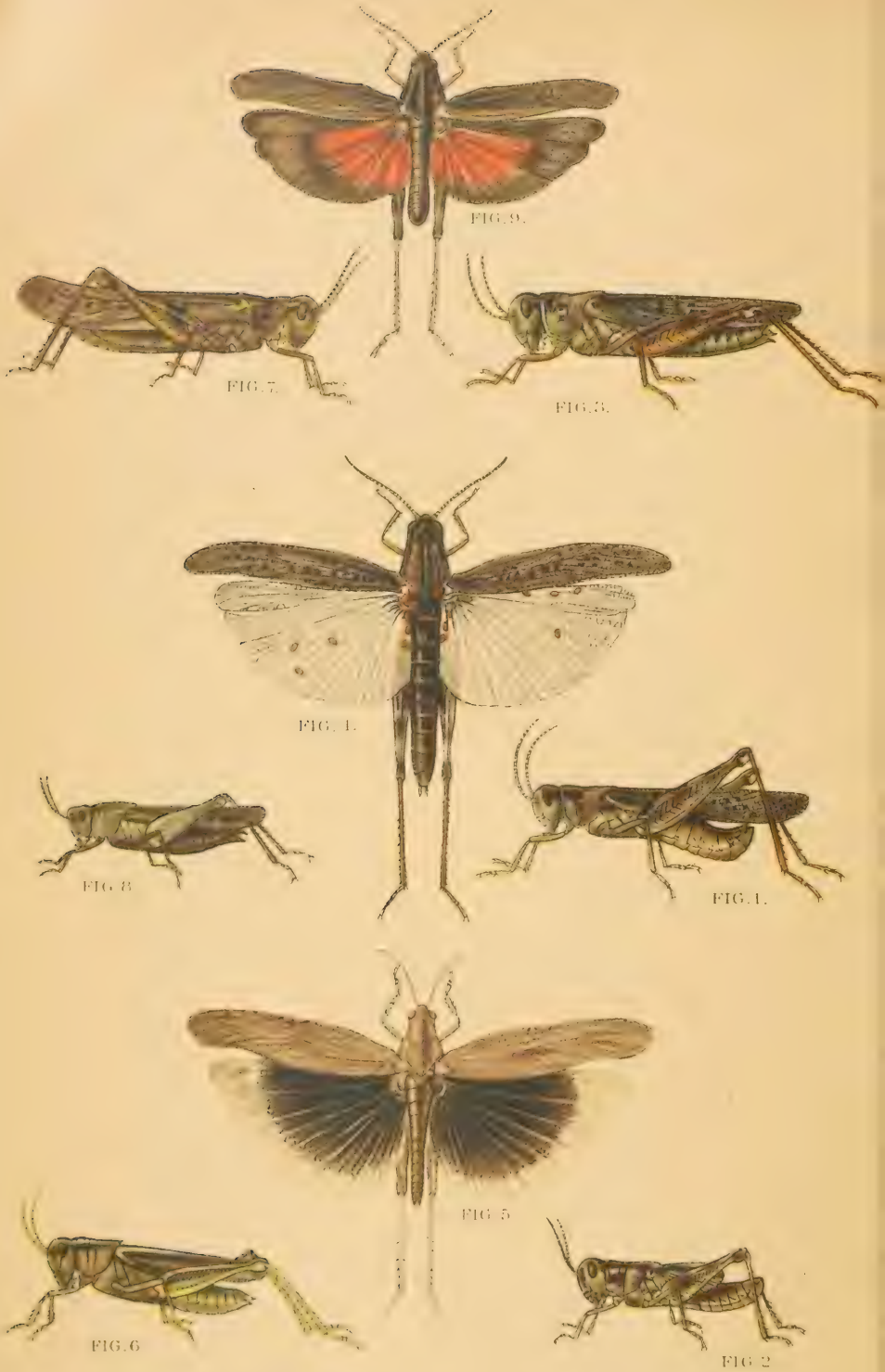
26th bugs were found in all plats upon the millet which was then well up, and it was also found that the wheat was injured somewhat in spots by the emulsion, but not sufficient to annul the experiment. It was later harvested and threshed. I believe that if the millet had been planted earlier, perhaps at the same time as the wheat the bugs would have been effectually prevented from entering the plats. About July 21st the grain crop on the farm was harvested and the Chinch Bugs migrated to corn in large numbers. At this time numerous complaints began to reach us from farmers in the central, eastern and southern parts of the State. On August 7th at the request of the late John Woodbury representing the St. Francis Milling Company, I went to that place and found the pest in great numbers. Upon the farm of David Stewart the bugs had reached the 15th row of corn as they had also on the farm of W. M. Corbin. Upon the place of John McDonald I found the bugs in corn as far as the 25th row and he stated that he had lost 25% of his Scotch Fife wheat through their injury and that the remaining wheat was hardly marketable. He further stated that July 28th was the date when he first observed the bugs migrating to the corn. We note in this connection that the habits of this pest differ in different latitudes. In eastern Kansas for instance, the migration is about two weeks earlier. Mr. McDonald claimed that where the bugs were congregated about pigeon grass in the corn and elsewhere they could be killed by covering to the depth of three inches with dry sandy soil. This may be so where the soil is very sandy or dusty, but a trial upon my part later, at St. Anthony Park, failed to corroborate this statement. Farmers in this section were shown how to make a dust furrow and tar line and some availed themselves of the information immediately. Thousands, yes, millions of bugs were observed migrating in the vicinity, yet it was reported that the pest was even worse north of St. Francis in Isanti county. On August 14th James Hanna near Forest City was visited; he stated that he would lose at least one-half of a twelve acre piece of fodder corn owing to the injury caused by the Chinch Bug. He further said that much of the injury ascribed to Chinch Bugs was really due to Hessian Fly, farmers in that neighborhood not being so familiar with the fly as they were with the former insect.

REMEDIES AND MEANS OF PREVENTION.

We do not know of any practicable means of killing the Chinch Bugs in the grain at present. In this connection we will say that the sending out of diseased Chinch Bugs has been abandoned, it having been found that the results were not sufficiently practical. The insects however may be trapped and killed without much labor after they leave the grain and start to attack the corn. Plow a furrow around your corn in such a way that the steeper side is towards the corn; drag a small log back and forth in this furrow until it becomes very dusty; it must be kept dusty. With a post augur bore holes ten or twelve inches deep or even less, along the bottom of this burrow at intervals of about a rod. If the furrow is well made the bugs cannot cross it and finally collect in the post holes where they may be killed by kerosene or hot water. In wet weather a dust furrow is impossible. At such times the bugs may be stopped by means of a tar line.

Tar can be purchased of the Minneapolis Gas Company for $4.50 per barrel, barrel included; for $3.75 per barrel without container. Pour tar to the width of two or three inches next your corn field or upon the side of the field attacked by the bugs. While this tar line remains sticky bugs will not cross it. The first tar applied will sink into the ground probably and the line will have to be renewed occasionally; that is it will have to be kept sticky. Bore post holes at the side of the tar line away from the corn and the bugs traveling along the line to find a means of crossing will fall into these holes where they may be killed. Even if the bugs have reached the outer rows of corn they may be stopped by the dust furrow or tar line between these outer rows and the remaining corn. The bugs on the outer rows may be killed with kerosene emulsion, one part emulsion to ten parts of water. Pure kerosene may also be used if one does not care to save the corn. It is certainly desirable to kill these bugs on the outer rows thus lessening the bug crop the following year.

It has been claimed that a rope kept saturated with kerosene and placed on the ground on the side of the corn which is being attacked, will form an obstacle which they will not readily cross. Some stock will not eat the stalks covered by the bugs, and even if they did the majority of bugs would escape to perpetuate their



SOME LOCUSTS OF MINNESOTA

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kind and thus make trouble for the farmer the following year. Farmers should practice clean farming; that is, in the fall rubbish should be burned as far as possible. The Chinch Bugs hibernate in rubbish collected in corners, in old straw, in hay stacks, in corn shocks left in the field, etc. Fallen leaves in timber also afford winter quarters, and it will be found that grain fields next these sources where the bugs pass the winter will probably be the first to be infested the following spring.

Recipe for Kerosene Emulsion: Dissolve one-half pound of soft or hard soap in one gallon of water, boiling it thoroughly. When the soap is dissolved remove the liquid from the fire and when boiling hot add two gallons of kerosene. This should now be mixed thoroughly by pumping it vigorously through a force pump or spray pump. This may take five minutes. It should be, when properly mixed, like thick cream or clabbered milk. This stock emulsion will keep some time, many weeks in fact, and can be used as desired.

GRASSHOPPERS OR LOCUSTS.

The people of the Red River Valley and of counties adjoining have the unusually wet Spring to thank for freedom from these pests. This year injury from Grasshoppers has been confined to a few localities.

Perham, Otter Tail county which always leads complaints of this kind, sent in the alarm through its county commissioner about June 15th, and the Entomologist at once went to that place. Hoppers were found very plentiful *on the old stubble.* These were all the Lesser Migratory or White Mountain Locust (*M. atlanis*) and for the most part past the fourth molt, although some were found considerably younger. The most threatening area in this vicinity was a tract of unplowed stubble containing 240 acres owned largely by nonresidents, who will not plow. Some farmers were found in this vicinity plowing in order to turn under the young hoppers, but all expressed uneasiness at the near presence of such a large tract of unplowed land, which is always a fertile breeding ground for the local forms of Grasshoppers.

The situation was so serious that upon consultation with the

Governor and the Director of the station, it was determined to plow this tract at the State expense and thus not only avert immediate loss but also reduce if possible the numbers of Grasshoppers which would otherwise be on hand to do mischief next year. The most threatening tract (about 200 acres) was then plowed. In the neighborhood of Perham there are altogether about 600 acres of this unused land. Wherever such is found it is a constant menace to farmers who are making every effort to keep this pest within bounds. It would be bad policy for the State to always plow these lands not used and I firmly believe that the only solution to the Grasshopper question is the making of a law which will oblige land owners to plow stubble found to contain Grasshopper eggs in the fall or early in the spring. In every grasshopper infested locality visited this summer the Entomologist met with this request from the farmers. Such a law would put an end to the pernicious practice of the State plowing or furnishing free oil except in exceptional emergencies. Most farmers will gladly plow if nonresident speculators will do the same.

A visit to Otter Tail district thirteen miles from Perham showed a condition entirely different from what prevails in the latter place. Here I found every acre in crops; no stubble land and consequently no Grasshoppers, disregarding the comparative few in grass along the roadsides. It is a matter worthy of note that the losses from locally hatched grasshoppers are confined largely to "pioneer districts," to the frontier of farming land as it were, where conditions are not settled, where property is changing hands or where the population is shifting and where there are very large tracts of land far from market, owned by individuals who either cannot or will not cultivate all their arable land. It is where these conditions prevail that the Lesser Migratory Locust (second only to the Rocky Mountain Locust in destructiveness) gets in its work and always will in favorable seasons unless compulsory plowing is resorted to. These are the conditions which prevail at Gentilly near Crookston, in Polk county, and more particularly in the Hill River district twelve miles northeast from McIntosh in the same county. At Gentilly on June 26th I found the Lesser Migratory Locust abundant and causing injury upon all well drained, sandy ridges where the eggs were not spoiled by wet weather last

spring. On the farm of Eli Benoit wheat next the stubble as well as beans, barley and young flax were eaten.

It was however in the Hill River district near Lindsay P. O. that farmers suffered the most. Here a tract extending one-half mile east and west and two miles north and south was almost swept of vegetation. Young flax, grass, wheat, barley and oats were mowed down and at the date of my visit, June 26th, the farmers

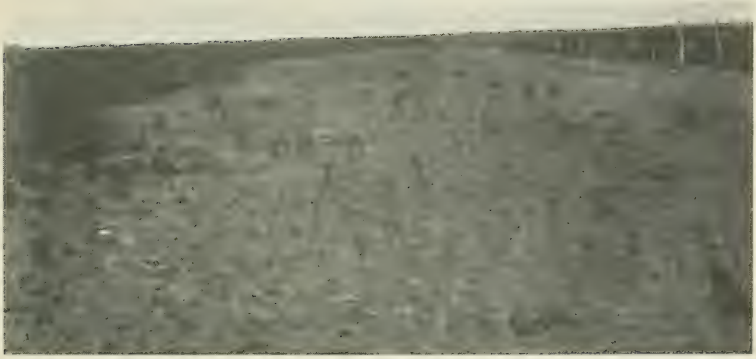

Fig. 12.—View of flax field near Gentilly, one-third of which has been eaten by grasshoppers.

were complaining bitterly of a 300 acre piece of stubble which had been allowed to lie fallow for two years or more and was very evidently the breeding ground of the pest. In places I found the ground brown with young hoppers not yet ready to fly, and the area referred to presented a scene of desolation not easily forgotten. These young hoppers were working south and on each succeeding visit I found their limit to be further south.

Farmers in this neighborhood worked heroically in the fight against the unwelcome visitation and about 800 gallons of oil was distributed by the Entomologist through the county commissoners. This oil was judiciously used, but the numbers of the insects

were legion, and although the hopper-dozers were run back and forth over the grain all day and day after day, and bushels of

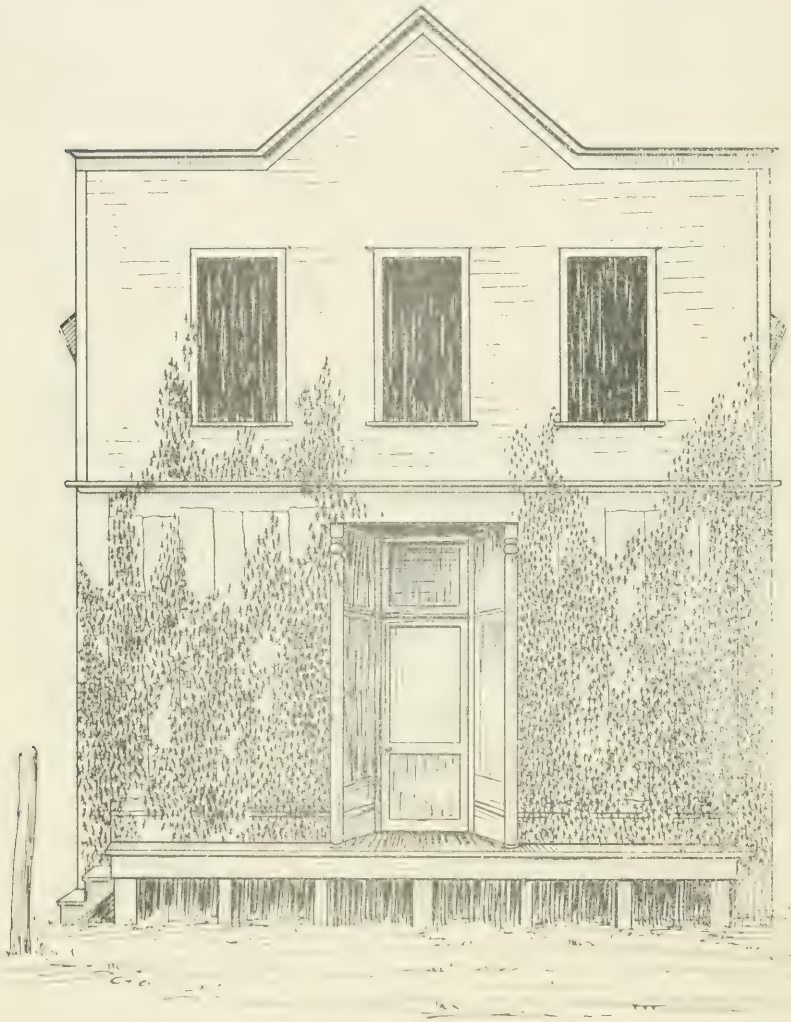

Fig. 13.—Young grasshoppers gathering by the thousands on the front of an unfinished store in the Hill River District on a rainy day.

oily corpses dumped upon the road, the pests appeared to be almost as numerous after treatment as before.

With the exception of a slight outbreak near Twin Valley in Norman county, which the Entomologist found to be not serious, an early and limited attack near Glyndon in Clay county and the crisis at Perham which was promptly met by plowing, Gentilly and the Hill River district were the only places known to be seriously affected.

As stated above the Lesser Migratory or White Mountain Locust was the offender and was practically the only locust found on the stubble. In grass and other rank growth (in one instance in a clover field in large numbers and also in timothy) I found the Two Striped Locust *M. bivitattus* (see colored plate); some few specimens of *Chortophaga viridifasciata* (Fig. 14), have also been seen and later the always numerous Red-legged Locusts, *M. femur*

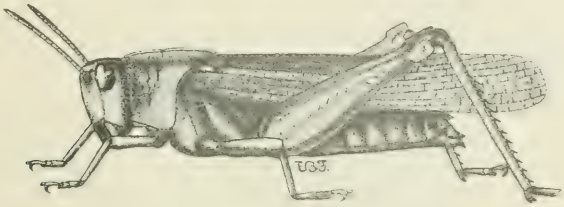

Fig. 14.—*Chortophaga viridifasciata*, form *virginiana*, female. Lugger.

rubrum. The usual quota of Carolina Locusts so often mistaken for the Rocky Mountain species were observed everywhere.

In July I visited this locality again. All the grain had headed but was still in the milk. I then found the hoppers winged and in enormous numbers about one-half mile south of where I had first seen them. They were feeding upon the soft wheat kernels and four out of every ten heads of wheat were being preyed upon by hungry individuals. As far as one could see and observe such small objects in looking out over the grain, grasshoppers could be distinguished by the thousand (see Fig. 11) and it is in the stubble here later, undoubtedly, that eggs were laid. I also learned at this time that the pests had spread further west beyond the broken belt of timber which had formed a temporary western barrier.

My last trip to Hill River was on Sept. 3rd after harvest. I then learned that hoppers were observed laying their eggs late in

July on the stubble. Unfortunately a heavy storm prevented an examination for the eggs. One of the farmers whose loss perhaps represents an average in this district, told me that he had lost about one-third of his wheat crop, nearly one-half his oats and fully one-half his barley through the ravages of Grasshoppers. Serious as this loss is, it must be admitted that the outlook in the earlier part of the season was much more threatening; in other words, the farmers in this district really got larger crops than they had anticipated.

All Locusts, while they vary as to date of egg laying exhibit

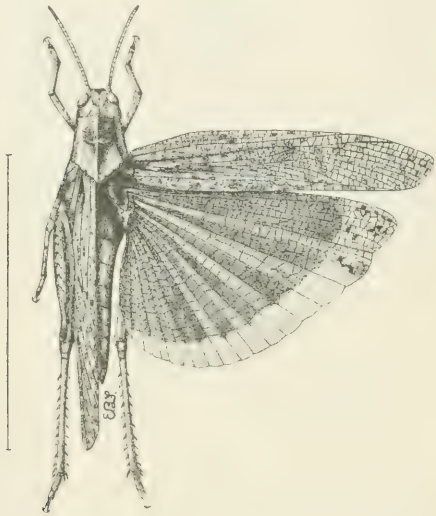

Fig. 15.—*Dissosteira carolina,* female. Lugger.

practically the same method, well shown in Fig. 58. It will be seen that the eggs are laid in a pocket in the surface inch of soil. The young hopper upon hatching invariably works upward. The significance of this fact in connecton with plowing is at once apparent, for the plow turns the bottom of the case up, thus affording no exit for the young hopper. Many of our people mistake the large Locust, notably the Carolina Locust, *Dissosteira carolina,* Linn., for the destructive Rocky Mountain variety. A comparison of the accompanyng illustration (Fig. 15) with the excellent colored plate, (Fig. 7) will show the difference between these two. It is well, however, to bear in mind that all hoppers are

injurious, their ability to do injury beng directly proportionate to their numbers, but only a few species ever become numerous enough to cause serious injury.

A word about hopper-dozers may not be out of place as I have met a number of farmers not familiar with their construction.

The drawing given, Fig. 16, will explain their structure almost without the use of words. The material is galvanized iron. The pan may be 8, 12 or 16 feet long. The larger pans are divided into compartments by soldered partitions, thus preventing the oil from running to one end on sloping ground and spilling. The back of the pan is about 4 inches high and the front is turned up about 3 inches. A 4 inch board is fastened to the under side of the pan at each end, the broad surface acting as a runner. These

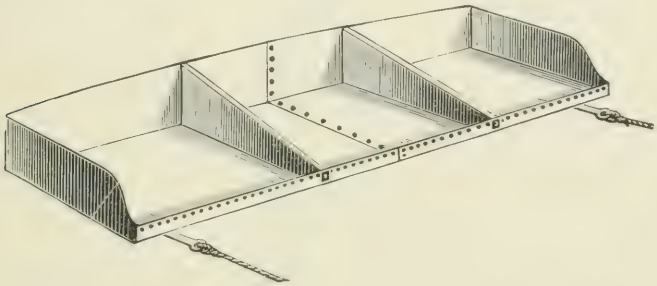

Fig. 16.—Large hopper-dozer with partitions (after Riley).

pieces project in front and to them ropes are tied for drawing the machine. Early in the season one horse is used, later when the hoppers get more active two are used, one at each end, so that the insects, startled by the horses, will jump for the main part towards the center and be caught by the pan. Uprights two feet long at the back of the pan, not shown in figure, support a white cloth which serves to attract the Locusts and to prevent their flying completely over the hopper-dozer. In this connection it may be said that it is economical to use but little oil. That is, if water to the depth of two inches say, is placed in the pan and enough oil poured upon that to make a thin film, it will be quite as effective as if it were all oil. For, even if the grasshopper barely touches the oil and then hops out, he is sure to die. Some of the farmers in the Hill River district used as many as 12 or 15 gallons of oil daily, whereas if water had been used as above indicated, five

gallons probably would have been all that was necessary. Every farmer in districts likely to be affected should have a hopper-dozer ready for use in the spring and not postpone the making of one until the pest is upon him and every one, including himself, is too busy to stop for the work. These machines can be used until the grain is fully one foot high without injuring it. They cost all the way from $4 to $16, depending upon the size, the weight of the iron and the cupidity of the firm making it. It should be borne in mind that as useful as the hopper-dozers are, they should be regarded in the light of a make shift for use in an emergency, since fall plowing when properly done by *all* farmers in a neighborhood is a sure method of extermination.

Fig. 17 shows a model of a new kind of hopper-dozer invented by a Minnesotan. The driver sits behind at end of the

Fig. 18. — *Melanoplus spretus;* dorsal view of end of male abdomen.

Fig. 19. — *Melanoplus atlanis;* dorsal view of end of male abdomen.

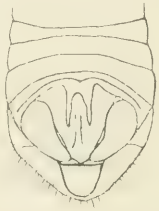

Fig 20. — *Melanoplus femur-rubrum;* dorsal view of end of male abdomen.

pole and two horses push the machine ahead of them. A strong fan blows the young hoppers against the bottom of rollers which crush them, the rollers being cleaned automatically.

There are times when the hopper-dozer can be used to better advantage than at others. A cold raw day, for instance, does not offer favorable conditions. Again, when hoppers are completely winged and fly a long distance when disturbed which, by the way, is after most of the injury has been done, dozers are of practically no use. It was to farmers owning hopper-dozers that oil was furnished free by the Entomologist, each farmer applying to his county commissioner for an order for oil on a local dealer. The price of oil ranged all the way from 9 cents per gallon including the barrel at Minneapolis to 11.1-3 cts. at Perham without container; 14¾ cents in barrel lots with barrel at the Standard Oil Co.'s Warehouse in Crookston; 15 cents at Gentilly; 14 and 15

at McIntosh, and 20 cents at Twin Valley where they claimed to have no cheap grade.

I take pleasure in acknowledging helpful co-operation upon the part of Mr. Sawyer at Perham, Mr. Remi Fortier at Gentilly, Mr. McCarty at McIntosh and Mr. E. L. Tomtengen at Fossum,

Fig. 21.—A Robber-Fly destroying a Grasshopper, enlarged. Original.

county commissioners, who assisted me in my work at these various points.

Figs. 18, 19, and 20, show differences in details of structure of the abdomens of male specimens of the Rocky Mountain Locust, Lesser Migratory Locust, and the Red-legged Locust which help to distinguish them.

NATURAL ENEMIES OF GRASSHOPPERS.

Like many other pests the increase of Grasshoppers is retarded by parasites, both animal and vegetable, and by predatory enemies which do much to lessen their numbers. The greater the number of hoppers the greater the number of enemies to prey

Fig. 22. Blackbirds coming to the feast. **Original.**

upon them. It is a notable fact that wet weather casts a gloom over these insects. As though they foresaw in it their own danger, they are sluggish and inactive, thus giving the grain a chance to grow. At such times bacteria and fungus diseases carry off

very many. It is at these times that they gather in numerous numbers upon fences, telegraph poles and buildings. Our illustration,

Fig. 23.—Crows in stubble field.

Fig. 13, shows the front of an unfinished store in the Hill River district which was almost covered by Grasshoppers upon a rainy

Fig. 24.—A frog eating young grasshoppers in stubble field. Original.

day early in the season. Among the numerous foes to Grasshop-

pers can be mentioned the Red Mite which fastens itself on their wings and other parts of the body (see Fig. 4 of colored plate), predatory Beetles, Robber Flies, (see Fig. 21) *Tachina* parasites, Flesh Flies and Bee Flies, and, as an internal parasite, *Gordius* or the Hair Snake, which popular belief used to regard as a metamorphosed horse hair. The writer has seen a specimen of *Gordius* in California emerging from a large Locust common in that State.

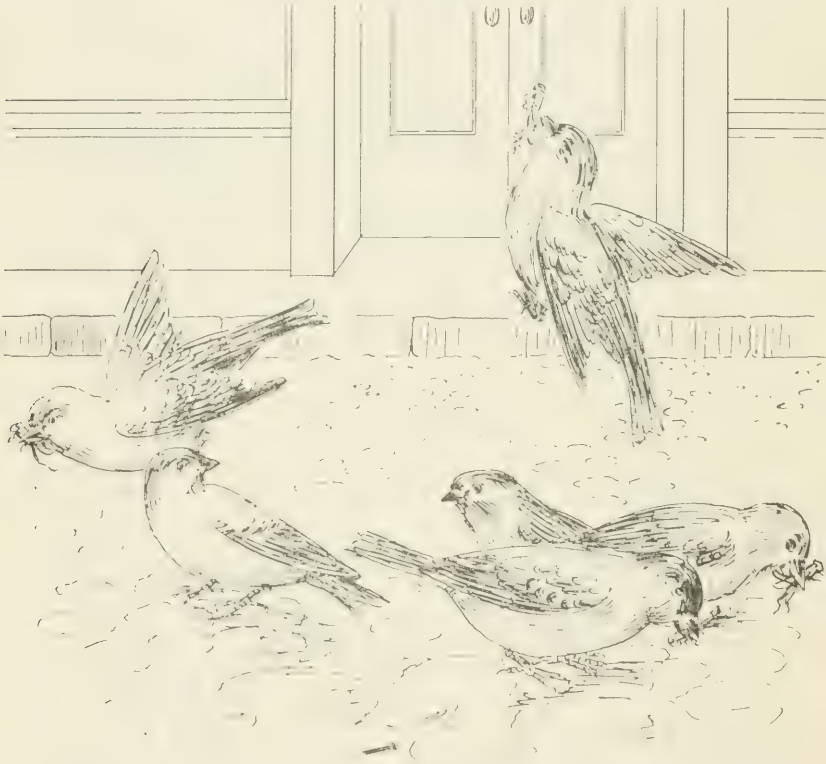

Fig. 25.—English sparrows catching grasshoppers in the streets of Crookston. Original.

Turning to vertebrate enemies we note poultry, Prairie Chickens, Hawks, Black Birds, Crows, Meadow-larks (the writer observed an Oriole helping himself this summer) some Gulls and Terns, Frogs, Snakes and Skunks. I have even observed the much despised English Sparrow catching quantities of them in the streets of Crookston.

Natural enemies, however, are not sufficient and farmers should know the best methods of combating a pest which is at times so serious.

PROTECTIVE AND REMEDIAL MEASURES.

Fall plowing of stubble or early plowing of the same in the spring before May 10th is the safest, best, and simplest method known to prevent the young hoppers from issuing from the egg cases. Co-operation in this, as well as in the treatment of all insect pests is absolutely essential. If one farmer plows and his neighbor does not, the work of the first is thrown away.

Young hoppers while very small, before they are large enough to avoid the plow, may be plowed under. It is advisable in this case to begin at the edge of the field and plow towards the center.

When infested pastures cannot be sacrificed to the plow the hopper-dozer can be well used. Vegetable gardens lying within

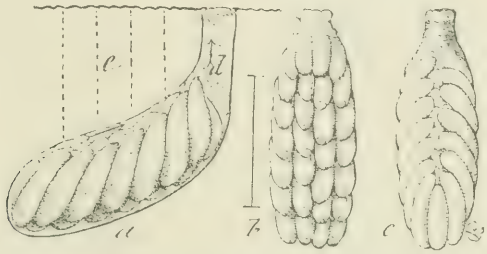

Fig. 26.—Egg-mass of Rocky Mt. Locust—(a) from the side, within burrow; (b) from beneath; (c) from above; (d) indicates the natural exit for young locust if the soil is compact, and the dotted lines (e) the direction of exit in loose soil; enlarged (after Riley).

an affected area, may, if the locusts are not very numerous, be saved by spraying something distasteful to the insects, like a well shaken mixture of kerosene and water or kerosene emulsion, upon plants not injured by such an application, or by poisoning with Paris Green vegetables whose parts reached by the poison are not used as food.

Wheat land in which Grasshoppers are numerous should be carefully examined in the fall for Grasshopper eggs, which are found near the surface of the soil not more than an inch from the top. Any doubt which the farmer has may be removed by sending the

objects suspected to be eggs to the Entomologist at the Experiment Station.

Before closing the discussion on Grasshoppers, I wish to call attention to an error which sometimes creeps into the press. The Entomologist was reported this summer as having gone north to "combat the Seventeen Year Locusts." To the best of my knowledge that insect does not occur within this State, though we have

Fig. 27.—*Cicada tibicen* Linn. Male and female. Lugger.

several forms resembling it. It looks like the accompanying figure, is not a true Locust, but a *Cicadid,* belonging to the great order of Bugs, one group of insects.

What we commonly call Grasshoppers are really Locusts belonging to the order *Orthoptera,* Family *Acrididæ,* and the true Grasshoppers are the more slender, greenish insects with long

Fig. 28.— Common Meadow Grasshopper (*Orchelimum vulgare*), male. Lugger.

horns or feelers seen on bushes and herbage generally, (Fig. 28); nevertheless we will probably go on calling Locusts "Grasshoppers" to the end of the chapter.

EXPLANATION OF COLORED PLATE.

The colored plate found at the beginning of this article has been prepared in order to show farmers the exact appearance of some of the more common locusts of the State, a few of which are so closely allied as to be difficult to distinguish by an amateur.

Fig. 1. Lesser Migratory or White Mountain Locust (*M. atlanis*). Somewhat enlarged.

Fig. 2. Young (pupa) of same; slightly enlarged.

Fig. 3. Red-legged Locust (*M. femur-rubrum*); enlarged.

Fig. 4. Same, enlarged, wings spread, showing parasitic mites.

Fig. 5. Carolina Locust (*D. carolina*); pale form.

Fig. 6. Two-striped Locust (*M. bivittatus*); reduced.

Fig. 7. Rocky Mountain Locust (*M. spretus*); slightly enlarged.

Fig. 8. Green-striped Locust (*C. viridifasciata*); reduced

Fig. 9. Coral-winged Locust (*H. tuberculatus*); reduced.

THE HORN FLY.

Haematobia serrata, R. Desv.

A small fly resembling the House fly but considerably smaller which attacks the shoulders of cattle and the back near the tail causing irritation, sore back and rawness of the flesh; dark colored

Fig. 29.—Horn fly (*Haematobia serrata*). Lugger.

animals appear to be the worst affected. Eggs are laid in freshly dropped manure, the flies darting to the manure, ovipositing, and

immediately returning to the cow or steer. The habit these flies have of resting on the horns, if horns are present, has given them the above name. It should be noted, however, at this time they cause no injury whatever but have simply chosen a secure retreat where they cannot be disturbed. Their position while biting is characterized by more or less extended wings; when resting on the horns the wings are closer together pointing backward.

This fly introduced into this country about 1886, has become very numerous and troublesome in this State. The writer has met with it at St. Anthony Park, Alexandria, Fergus Falls, and Luverne and has received reports of its occurrence in various localities. It appears to be generally distributed over the State and bids fair to become a very noxious pest. With a view to finding

Fig. 30.—Horn Flies on horn of cow, enlarged. Original.

some effective means of keeping it from the cattle, the Entomologist tried several experiments this summer at the station with good results. The various patent preparations on the market are good as far as they go, but quite expensive and not lasting. A cow sprayed at milking time will stand quiet enough, but a few hours later the effect of the "fly cure" has gone. I am further informed by a well posted dairyman that when these remedies are used in sufficient quantities to produce a lasting effect they injure the skin of the animal upon which they are applied.

Various simple compounds were tried at the Experiment Farm. These, with results, are here given. Rancid lard, not ef-

fective. Lard 1 lb. with oil of Pennyroyal 10 c. c. (one tablespoonful and oil of Eucalyptus 10 c. c. added,—effective for twenty-four hours or longer, but expensive. Pennyroyal costs $1.75 per lb. and Eucalyptus Oil $1.20 per lb. Lard 1 lb. mixed with 4 oz. of Pyrethrum, quite effective, in one case affording exemption to one of a herd for three or four days. This also is somewhat expensive. It must be borne in mind, that an animal so treated among a large number not treated, is hardly a good criterion, for the flies would doubtless be much more persistent in their attack were there not more inviting backs present in abundance. Lard with oil of Pennyroyal and oil of Eucalyptus was also used on

Fig. 31.—Stable fly (*S. calcitians*). Lugger.

a family cow to find effects of isolation, with good results for twenty-four hours, "but did not keep them all off." Lard 1 lb. kerosene ½ pint, mixed thoroughly until a creamy mass was formed, gave excellent results lasting two or three days. This was used on a few herd cattle and upon a family cow; in all cases it worked well. All of the above combinations were applied with a cloth or with the bare hand, smearing each animal over back, shoulders, hind quarters, neck and flanks. About ⅜ of a pound was used for each full grown creature. Manifestly the use of any or all of these on a large scale would be impracticable, so we

turned to fish oil. Fish oil costs in Minneapolis 45 cents per gallon in barrel lots; 48 cents by the half barrel and 60 cents for a single gallon. This vile smelling oil was used alone, being sprayed on the steer and was not very effective compared with the solution we prepared by adding one part kerosene to three parts fish oil. One man can spray an animal with this in two or three minutes provided the animal is held to prevent its moving about. An examination of a steer two days after treatment with this mixture (1 part kerosene, 3 parts fish oil), showed it to be absolutely free from flies, while other cattle not treated all about it were suffering.

If I were keeping two, three or four family cows I should not hesitate to use the kerosene and lard mixture mentioned above.

Fig. 22.—Blow fly (*S. carnaria*). Lugger.

A large herd could be better treated, of course, with the spray pump and the more disagreeable fish oil and kerosene mixture. The lard used in these experiments was rancid, perfectly good for the purpose but not saleable for culinary use. Not only Horn Flies but the Stable Fly, *Stomoxys calcitrans*, Linn., and the common Green Bottle, *Lucilia cornicina*, Fab., and Flesh flies, *Sarcophaga carnaria*, Linn., were effectually kept at a distance by the treatment referred to above as the best.

Treatment in the case of very large herds is naturally beset with difficulties. Moist weather, by keeping the dung moist for a longer period is most favorable for the development of the Horn Fly, while any method of destroying the dung will lessen the chances for its successful increase. A decoction of a species of Smart Weed (*Polygonum pennsylvanicum*) was tried, one pound in three quarts of water boiled down to two quarts, with absolutely no results. It is to be hoped that none of our farmers will be

Fig. 33.—A species of Smart Weed (*Polygonum pennsylvanicum*).

led to follow the example of a gentleman living at Hills, Minnesota, who unwittingly applied machine oil to a valuable horse with very serious consequences, the hair coming off completely and leaving the skin in a raw, sore condition. We realized no bad effects in this way after treatment with the above compounds.

This year the Horn Fly began to be troublesome early in August. A few individuals can still be observed about the cattle at this date, Oct. 6th. It is perhaps of interest to note the fact that while Flesh flies and Green Bottles frequented the surface

of comparatively fresh and drying dung in egg laying, the Horn fly visited it for the same purpose only just as it struck the ground, it required a quick eye to note their actions before they were back again upon the cow.

Prof. Weed, in Bulletin No. 28 from Mississippi, speaks of the noticeable fact of black cattle being more affected than light-colored animals, and states that he found a mixture of crude Cotton Seed oil or fish oil and pine tar mixed, two parts of former to every one of the latter, successful. It took him half a minute

Fig. 34.—Green-bottle Flies ovipositing on dung, enlarged. Original.

to apply this to each animal, using a large paint brush for the purpose. The cost of the application exclusive of labor was three-fourths of a cent per head. He claims that the efficacy of this lasts for a week or more.

From another source it is learned that it is practicable to mix lime copiously with dung in small stock yards, and perhaps also

in pastures where cattle gather in one place for shade. In a report by Messrs. Riley and Howard in 1889 the statement is made that a spadeful of lime on a cow dung will kill all the larvae therein.

To kill the flies, Mr. Weed, in 1895, used a mechanical mixture of kerosene and water (2-10 in Kerowater Sprayer). The milch cows of the Station herd were sprayed with this daily for seven days, effort being made to have the spray hit the flies. The pests were killed in this way and their numbers so reduced that after the seventh spraying practically no flies could be found nor were they again numerous that season. Kerosene Emulsion, one part emulsion to 6 or 8 of water, would probably accomplish the same results.

A NEW STRAWBERRY PEST.

Harpalus pennsylvanicus, De G.

This beetle hitherto so useful in eating noxious larvae that we have unhesitatingly accepted him as our friend and classed him for years under the head of beneficial insects, has this year for the first time apparently in Minnesota developed a most reprehensible habit, which bids fair to put him under the ban. It seems that though preeminently carnivorous in taste it is enough of a vegetarian to eat the seeds of the rag weed, (*Ambrosia*). From the seeds of this humble plant it was but a step to eat the seeds of the strawberry, a patch of which plants may have been near at hand. After tasting the pulp of the strawberry in eating the seed we can hardly blame him for acquiring a fondness for this luscious fruit.

On July 10th I received the following letter from Mr. Henry Grinder of Hinckley: "Dear Sir:—Can you tell me any way to get rid of the Black Beetle which is eating my strawberries? He works at night. The seed of the berry is all he seems to care for, he cracks that and eats the kernel of it. They hide in the mulching between the rows in the day. They are very plentiful this year. Is there anything I can put on the plants that will drive them away and not injure the berry? They have destroyed over two-thirds of the berries. Please let me know if there is anything I can do to stop them." Later, under date of July 13, he again

writes as follows: "I have grown berries here for four years and this is the first year they have troubled the strawberries."

In response to my request for specimens of the insects doing

Fig. 35.—*Harpalus pennsylvanicus*, enlarged 4 times. A. G. Ruggles.

the injury, he sent me some specimens of this beetle. It was hard to believe that this well known friend had developed such a trick,

Fig. 36.—Strawberries showing the work of *Harpalus*. On the extreme right an uninjured berry (after Slingerland).

but investigation of the literature on *Harpalus*, revealed the fact that our little friend had shown this bad trait elsewhere.

In Ohio in 1900 members of this genus (*H. calignosus*) were reported as injuring strawberries, and probably attacked strawberries before that date.

In 1892 *Harpalus ruficornis* caused trouble in the same way in Holland, and Miss Ormerod mentions the same injury in England in her Reports for 1894, '95 and '97-'99.

REMEDIES.

There are various ways of combating this pest in the strawberry patch. They work entirely at night and during the season of their abundance it is barely possible that the lantern trap may be effective, though I have not had any experience with the same. It is worth trying. The lantern trap consists of a pan two-thirds full of water upon which water a generous layer of kerosene has been poured. This pan is put upon a post in the strawberry patch about two feet above the ground, say, and above the pan is suspended a lantern; or the lantern rests upon a brick placed in the pan. The beetles attracted by the light fall into the kerosene and are killed. Several such traps put about the strawberry patch might materially reduce the number of beetles. Bran mixed with water, sweetened with molasses and poisoned with Paris Green if distributed under boards and other protected situations in the strawberry patch is also said to be fairly effective. It would of course be fatal to any fowl which had found its way into the strawberry patch.

Some berry raisers have put cheap meat such as lights from sheep, or calves, in basins, the basins being sunk in the ground up to their top. They are examined every morning and the beetles which fall into the pans collected and killed. This insect became at one time such a serious pest in Pennsylvania that children were employed to go through the strawberry patches and pick the beetles from under the mulching and elsewhere! Fifteen or twenty dollars or even three times those sums spent in this way, if it will save two or three or four hundred dollars on the strawberry crop is money well expended. Another suggestion is to place boards throughout the strawberry field and look under them every morning, catching and killing the beetles found there. If there is anything like Rag Weed growing about the strawberry patch it should be destroyed.

LAWNS INJURED BY GRUBS.

Lachnosterna rugosa, Melsh.

"What shall I do for my lawn?" is a somewhat common question here on the part of citizens, who see dead patches appearing in the green grass about their houses. These patches of sod have been killed and loosened from the underlying earth by the "White Grub," larva of the above named beetle.

LIFE HISTORY.

Both beetle and larvae are shown, much enlarged, in the photograph facing this page.

The egg is laid amongst the roots of the grass. The grub requires more than a year to attain its growth and at approach of cold weather is said to burrow quite deeply, beyond the reach of frost. As this would take it some six feet or more below the surface in this State, I have doubts of the accuracy of this statement. The pupal stage is passed under ground. The Beetle flies at night, for the most part, burying itself just below the surface toward morning where it passes the day to emerge again in the evening. Since it is principally males which are attracted by lights, lantern traps are not particularly useful as a measure against this pest.

My attention was first called to its presence about June 16, by noting the appearance of the lawn in front of the horticultural building at the Experiment Station, where I am told it causes trouble every year. I at once endeavored to find some means of combating it. The grass was drenched with kerosene emulsion, one part of emulsion to six of water. This injured the grass without killing the grubs. One part of emulsion to ten of water was tried with the same results. Tobacco water was also tried, ½ pound of stems steeped in one gallon of water was used without injuring either the insects or grass. Finally I turned to bisulphide of carbon with better results. I found that one ounce of bisulphide of carbon placed in a quite shallow pan and put under a tight box whose cubic capacity was 3458 inches, said box having been inverted over a dead patch of grass, killed all the grubs in the patch in three hours without in the slightest way

injuring the green grass with which the gas came in contact. In round numbers this is one part of the liquid to 1900 parts atmosphere.

An effort was made to use a large cloth covered frame four inches deep by four feet ten and ½ inches by thirteen feet ten inches previously employed in experimenting with Chinch Bugs, in order to cover a larger area of lawn. Under this 3 oz. 6 oz. and 8 oz. of bisulphide of carbon were used at different times, with exposures of three hours each time, this resulted in only a partial success as regards killing the grubs. Lack of success was undoubtedly due to the fact that the frame was not tight, the gas must not only have escaped through the cloth but the corners of the frame were badly jointed and we experienced difficulty in properly banking the edges next the sod with earth. I have no doubt, however, but that a frame entirely of wood with tight joints could be made of the same dimensions which would be as effective as the small box, under which the gas worked so successfully. In the case of the small box the criticism is made that it covers only a small area at a time. This is quite true, but if the injury is met with treatment as fast as it appears a small box is better than a larger one; furthermore, this treatment is not possible until the presence of the grub is made evident by the dying grass. Bisulphide sells for from 12 cts. to 15 cts. per lb. in 5 lb. lots in Minneapolis. Only one grade quoted here. Taylor's "Fuma" Carbon Bisulphide has been quoted in Cleveland, Ohio, at 10 cts. per lb. in 50 lb. cans.

Robins are very fond of this grub and can frequently be seen listening intently for any sound from beneath the sod which will betray the presence of the delicate morsel. Once heard it takes but little effort on the part of the bird to pull the grub from its retreat.

WOOLLY APHIDS.

ON APPLE: *Schizoneura lanigera,* Hausmann.

Was found this season in a few instances on young stock. This, the Woolly Louse of the apple, is one of the worst pests the orchardist and nurserymen have to deal with. It is found not only upon branches but also upon the roots where it forms gall-

like swellings. The woolly colonies on the branches can be seen during the entire summer and even late in the fall. They particularly affect water shoots, which, of course, are not allowed

Fig. 38.—Woolly Aphid (*S. lanigera*) on young apple.

to grow in a well kept orchard or nursery. Northern Spy stock is said to be immune.

During the summer the wingless females produce living young, females like themselves and without wings. Toward Fall

winged individuals begin to appear and later after a brood of males is produced the minute eggs are laid in crevices in the bark, on young shoots, etc. These eggs will give rise to a new generation the following season and it behooves the nurseryman to rid his stock of all Woolly Aphids before the egg laying stage is reached. See also Figs. 59 and 60 on page

Fig. 39.—Woolly Aphid on apple twig; enlarged.

REMEDIES.

The branch form can be kept in check by occasionally spraying with kerosene emulsion, one part to eight of water, or resin wash. Recipe for Resin wash: Boil 4 lbs. resin and 3 lbs. carbonate of soda (common washing soda) in one gallon of water until all the resin is dissolved. Then add gradually four gallons of warm water stirring all the time and continue the boiling until the mixture is the color of molasses. For Woolly Aphids use one

part of wash to six of water; for any other Aphid one part wash to ten or twelve of water; for Mealy Bug the same.

All sprays must be applied warm and with force in order to penetrate the woolly covering.

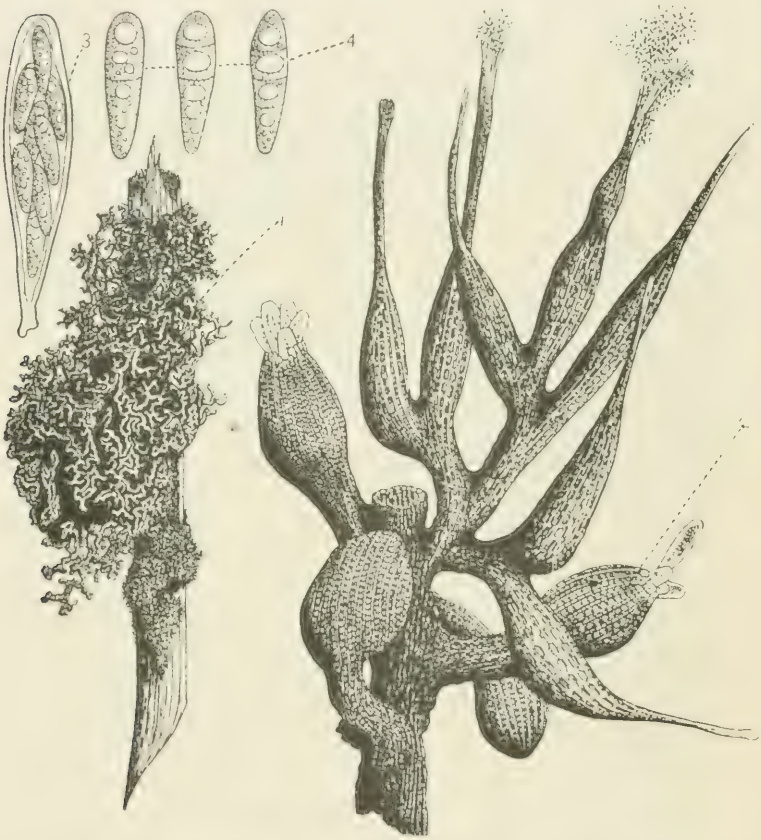

Fig. 41.—Spongy Fungus (*Scorias spongiosa* Schw.), found in the honey dew of *Schizoneura*: (1) natural size; (2) portion of fertile branch much enlarged; (3) *ascospores;* (4) three *sporidia* (from Ellis' Pyrenomycetes).

For the root form, bisulphide of carbon is now used. (Care should be taken not to injure the tree with this agent; consult the Experiment Station). Strong soap washes are also used on roots of nursery stock, etc.

ON ELM: *Schizoneura americana,* Riley.

Observed in a few instances on Elm trees.

ON ALDER: *Schizoneura tessellata,* Fitch.

A clump of Alders on the boulevard on the west side of the Lake of the Isles about sixty yards from the Peavey Stone Foun-

Fig. 42.—*S. tessellata,* winged and wingless individuals, much enlarged.

tain, Minneapolis, have been badly infested this season and are apparently dying as a result of injury from this insect.

This pest is commonly known as the alder blight. Like almost all plant lice, it elaborates a so-called honey dew from the sap of the tree, which exudes from two tubes on its back, and this honey dew, dropping on the leaves and branches below the insect, forms a favorable culture for a dark fungus growth, giving that part of the tree a blighted appearance, and it was from this fact,

probably, that the insect is called alder blight. Directly under the colonies of the insect, where the honey dew is the thickest, a thick, sponge-like fungus grows, which is said to grow nowhere else.* A pest of this sort is hard to eradicate, and calls for most radical treatment. The destruction of the worst affected trees and repeated sprayings with some such agent as kerosene emulsion, resin wash or whale oil soap, a treatment of the roots with the same agent would probably in time exterminate them. As will be seen from the photograph, they are a striking looking insect, for, while the bodies are dark green or black, they are so covered with this white woolly growth that the colonies look, for all the world, like patches of snow upon the branches.

In October I found the young swarming over the trunks and it would seem as if the Alders in that vicinity were doomed unless measures are taken for their relief.

THE STALK BORER.

Hydroecia (Gortyna) nitela.

The Caterpillar of this moth has been extremely troublesome this season. I found it in tomato vines, in hollyhocks, catalpa, golden glow, etc. It has also been known to work in potato,

Fig. 43.—*Gortyna nitela* Gu. From Div. of Entomology, Dept. of Agriculture.

aster, dahlia, castor bean; in short any plant with soft center is apt to suffer. It is even reported as attacking twigs of apple, peach, currant, etc., and is to be classed as a general nuisance.

Mr. Freeman of the University has identified this fungus as *Scorias spongiosa*, Schw. Harshberger, in Vol. 3 of the Journal of Mycology, reports it as occurring in the honey dew of *Schizoneura imbricata*, found on the Beech.

I obtained pupae from hollyhocks on the 11th of August, the adult emerging from them in the breeding cage Sept. 7th. The young Caterpillar on emerging is purplish with light stripes running along its body. As it gets older it becomes duller colored, and about midway of its length the color is such as to make that part appear diseased.

Fig. 44.—The larva of the Stalk Borer, enlarged.

Mr. T. L. Libbey of 8th St. S. E. Minneapolis, whose tomatoes were sorely threatened last summer, hit upon an ingenious method of killing the borer without injuring the vine. He had tried to reach the borer by introducing a wire into the mouth of its burrow, but found that the stem was so irregular in its growth that it was bruised and injured by this process. He then tried chloroform, injecting with a medicine dropper about one teaspoonful into the burrow and plugging the hole with cotton that the fumes might be retained in the burrow. This worked like a charm, killing the borer and beyond a slight browning of the vine at the point of application, no injury was occasioned.

The use of noxious gases such as those of chloroform and the more universally used bisulphide of carbon to kill fruit pests are becoming quite common. The latter gas has been used successfully in California against the Peach Tree Borer and no doubt would have been as efficacious against the Stalk Borer as was the much more expensive chloroform.

A SCARABEID INJURING CORN.

Ligyrus gibbosus, Dej.

On Aug. 7th the Entomologist received from Mr. J. W. Shu-

gard of Merriam Park a complaint that a Beetle was at work at the roots of his sweet corn and that in consequence the corn was wilting and the ears not maturing. One corn plant was sent to the Station which had at its roots 20 Beetles, pupae and larvae. Careful examination of this plant, however, failed to disclose any material defacement by the Beetles and I was led to conclude that the nature of the soil had encouraged the withering of the corn. A visit to Merriam Park later, however, convinced me that this was not the case particularly as the season has been a wet one and

Fig. 45.—*Ligyrus gibbosus.* From a pinned specimen; 4 times enlarged.

a careful study of the various hills assured me that the Beetle was to blame. While no corn stalk examined was actually bored into still there was evidence of slight gnawing of the stalk and a part of the roots had evidently been bitten off.

Mr. Shugard's experience with a lantern trap is interesting as showing the futility of such contrivances often advertised as a "sure cure" for all sorts of insect pests.

In four nights of trial in August he secured only 63 specimens of insects. 54 of these were moths; the remainder with one exception were small insects, the exception being a beetle. Neither the moths nor the small insects were sent to me by Mr. Shugard. Only one individual then of the larger number of beetles

which were flying in that vicinity, according to the statement of Mr. Shugard, was caught in the trap.

A most thorough trial of lantern traps has been made by the Cornell Experiment Station, to see whether they would accomplish all that the advertisers claim, and any orchardist or farmer thinking of buying one of these humbugs is advised to read the Cornell bulletin before purchasing.

This Beetle has been reported by Webster as feeding upon roots of carrots, by Weed as injuring corn in Mississippi and by Forbes as guilty of the same trick along with *L. rugosa*, in Illinois causing the corn to wither and turn yellow about the time it should be maturing.

The species under discussion was reported in 1898 as injuring corn in both Wisconsin and Louisiana. In Bulletin No. 33, Div. of Entomology, U. S. Department of Agriculture, F. H. Chittenden reports it as injuring the roots of Sun Flower and Sweet Potato in Ill., and the roots of the former plant in Neb., also roots of celery, carrots and parsnips in Indiana. The same bulletin quotes Prof. Bruner as stating that it has been quite destructive to sugar beet in localities in western Nebraska.

In view of what we know of the habits of this family I was not surprised to receive a letter from Mr. Shugard under date of Oct. 30, stating, in reply to certain inquiries mailed him, that in 1900 "cleanings from a horse yard were spread upon this plat of ground to the depth of about 2 inches and the yard was cleaned up every 3 or 4 weeks." He stated, further, that in 1901 a light application of horse manure was made, and that in the spring of 1902 about 3 inches of horse and cow manure was used.

MOSQUITOES.

A country containing as much water area as Minnesota will always suffer to a greater or less extent in localities with this troublesome pest, though it is well to bear in mind that it is not the deep ponds or lakes which favor its increase. In other words, since the larva or "wiggler" or "wriggler" as it is called, gets its food from the bottom and its oxygen from the surface and in consequence spends much of its time oscillating between these two

points, deep water would be a very undesirable feature. As the human family know only too well it appears to reserve its energy for use on them. The adult, at least the female does all the biting, the mouth of the male not being adapted to piercing the skin and sucking blood. An Italian worker, however, claims that in two species, the males also suck blood.

As to the length of life of the adult Mosquito, no general statement can be made, several having been kept alive for three weeks; evidently the natural life of the perfect insect lasts from 8 days to 3 weeks. This statement is only a general one; climatic conditions probably have great influence upon the duration of life.

Though our pretty lakes are not infested, their irregular shore lines where little shallow pools occur are ideal places, and where ever swampy land is found in the State, there as the reader probably knows, mosquitos occur in countless numbers. Further, only a handful of water being necessary for the development of several hundred individuals the following places, very apt to be overlooked, afford fertile sources for infection; drains, ditches, shallow ponds, puddles, post holes, depressions under sidewalks, watering troughs where water remains unchanged for some time, muddy holes made by the feet of cattle about watering troughs, water tanks, fountain basins where the use of the fountain is not and in fields and meadows, marshy places in meadows, uncovered sufficient to keep the water in motion and renewed, old basins, tin cans, bottles, etc., in rubbish heaps; a broken bowl or an old coffee pot lying unnoticed under a bush may be the source of hundreds. The fact that one-half pint of water in a cow's track in the meadow, may, if the water remains there ten days, or even if it almost all dries up and is then renewed by a slight shower, be the source of several hundred mosquitoes probably accounts for so many of these insects in land where apparently no water is present. Furthermore, the writer has a suspicion that inasmuch as water is not absolutely essential to the vitality of the egg, our mosquitoes like the Salt Marsh Mosquito, may lay their eggs in localities where their instinct tells them water will come later. Out of twenty-five or more species known to occur in the United States we find in Minnesota *Culex consobrinus, C. impiger, C. pungens, Anopheles quadrumaculata*, and probably others not yet described.

In Press Bulletin No. 15 issued by this department May 24th, the life history of the Mosquito tribe was quite fully discussed and need not be repeated here since a copy of that bulletin can be obtained by any citizen of the State for the asking.

The conditions here in this State and the bearing they have upon the life history of mosquitoes is being made a subject of study by this department, the date of appearance of the first brood, and the last, what species are represented, their method of hibernation, unsolved problems as to eggs, larvae, etc., as having a bearing upon the question of lessening the evil.

The best means to reduce the pest in any neighborhood is to drain and fill up as rapidly as possible all marshy places in the vicinity. The introduction of fish into shallow ponds affords a means of killing mosquitoes, for fish feed upon the larvae and pupae.

The evening of the shore line of ponds, making the same regular and thus destroying small inlets and wet depressions has also been suggested.

An effective remedy, but not a new one, is the application of kerosene to the surface of pools, drains, ponds, ditches, open cess pools and the like. Prof. L. O. Howard, U. S. Entomologist has brought this method into prominence, but beyond the establishing of certain important details, he does not claim any special originality in its use. It is said that one ounce of oil to every 15 square feet of surface will not only kill all the larvae, pupae and eggs in the water treated, but is fatal also to the adult female mosquito whose instincts prompt her to lay her eggs upon the surface of the water in spite of the presence of kerosene. The oil may be simply poured upon the water, preferably upon the windward side, and allowed to spread, or it may be sprayed. An objection to spraying is the fact that some oil is wasted and that vegetation is unnecessarily killed. Under some circumstances, however, spraying is certainly the best method, and in the case of low, hummocky land with water in innumerable small holes all over the field, it would be manifestly a herculean task to pour oil in each hole, and the spray is resorted to as the best and quickest method, new vegetation quickly taking the place of that killed by the oil.

How often should one apply the oil? It would seem that this is a matter easily determined by observation, for as long as a film of oil can be seen upon the surface, no further treatment will be necessary, and the volatility of the oil must be dependent in a great measure upon meteorological conditions. It has been suggested that one application every four weeks during the summer is sufficient. I believe that a more frequent treatment, perhaps

Fig. 46.—Pupa of Mosquito killed by fungus, enlarged.

once in three weeks is safer in this vicinity. As to the date of first application, that too is easily determined by observation. As soon as the wigglers are first seen or even earlier when the adult mosquitoes are noted about the water preparing to lay their eggs, then the oil should be applied. It is claimed that this method can be used with safety in the case of large tanks, the water in which is intended for drinking purposes, providing the water is drawn from the bottom of the tank, or a better way perhaps is to put a screen over such tanks. It is very evident that there must be co-

operation in this work, for it would profit but little if one citizen should treat all the stagnant water upon his place, while his neighbor across the fence leaves untouched, pools and ditches capable of producing millions of mosquitoes. It is interesting to learn that this pest must not necessarily feed upon warm blood. They have been observed puncturing dead fish and hovering about turtles when the latter were on the land. They appear to have a special predilection for beer and wine, and have been kept alive for some time on slices of banana. Evidence in the possession of Entomologists points to the probability that all Mosquitoes were originally vegetable feeders and that the blood sucking habit is an acquired one. Like other insects they are at times affected by fungus diseases which must lessen their numbers considerably. The accompanying photograph illustrates a pupa killed by a fungus growth. The writer found that many taken from a pool contaminated with sewage died in this way. In fact it is reported that fungus disease has been successfully introduced into ponds last summer for this purpose. The statement in the press that mosquitoes "are attracted by red and black colors and abhor yellow," must be regarded with some suspicion until it is corroborated by scientists. It is generally believed that mosquitoes do not fly very far from the place where they hatch. This has been disproved, at least of many of the species, and even if they do not the same result will be attained, that is their dissemination, through the agency of the wind. It is of further interest to learn that the larva or wiggler of some species have been known to live through winter and not to have been injured by frequent freezing. In fact, on the night of Nov. 16th the water in an out-of-door breeding jar which contained a larval mosquito froze solid. On the 18th the ice melted, disclosing our Culicid, not only none the worse for its freezing, but turned into a very active pupa.

The writer attempted with kerosene to abate the mosquito nuisance this last season in a neighborhood quite badly infested. A map was first made showing all the ponds and marshes in the vicinity, and the first application of oil was made May 24th (a little late possibly as subsequent events proved). The same ground was gone over again June 16th by an assistant in the absence of the Entomologist, and again on July 30th and again, the

places which were observed to contain larvae, on August 13th. This experiment was only partially successful. That is, immunity for a time was reported, but inability to be personally on the ground and make application more frequently, allowed the pest to emerge in large numbers during mid summer. An insurmountable difficulty, however, which presented itself was the presence in the neighborhood of vast marshy tracts where it was impossible for a man to walk, much less a horse hauling a heavy spraying outfit. *Until such places are drained and filled residents in such localities must expect more or less trouble.* Yet much might be done in the immediate vicinity of the house. Five gallons of kerosene and a little watchfulness will do wonders. Mosquito larvae and pupae were observed in the vicinity of St. Anthony Park in pasture pools as late as October 30, at which time imagos were plentiful, and larvae, or "wigglers," were found November 6.

Unidentified wigglers were collected August 11th, and kept under natural conditions in breeding jars, with water from the pond where they were captured, until September 5th, at which date all were dead. During that period from August 11th to September 5th, over three weeks, *none emerged.*

As to repellant applications for face and hands. Prof. Jno. D. Smith, of New Jersey, who has done and is doing much work in the line of mosquito experimentation, advises the use of Oil of Citronella, which he says absolutely keeps off all kinds of mosquitoes. All who have used it at his request, writes Dr. Smith, are loud in its praise. Caution must be used to avoid getting it in one's eyes. The writer has tried some laboratory experiments with Phinotas oil, simply to corroborate the published statement that one part of oil to 10,000 parts of water will kill mosquito larvae and pupae. This oil, made and sold by the Phinotas Chemical Company, is a secret compound which is undoubtedly superior to kerosene, and also more expensive, it being quoted at 40 cents per gallon. It was found that one part of the oil to 12,000 parts of water killed larvae and pupae. Phinotas oil sinks to the bottom in globules, which almost immediately rise, spreading out in a film on the surface, and forming as they rise a fine, white "precipitate," which permeates the water, killing all small organisms it comes in contact with. The accompanying photo-

graph will illustrate the action of the oil, and the appearance of the water at intervals of a few moments after application. Figs. 1, 2, 3, being taken within one minute of each other, and Fig. 4 a little later.

A sample left with the Station Chemist was reported as being a coal-tar creosote product, with a specific gravity of 1.03. The white "precipitate" observed when Phinotas is added to water (see photos), is the material separation of phenol derivatives.

The use of oil of some sort in this connection is no new thing. Kerosene, it is reported, having been applied for this purpose as early as 1847, and some kind of oil unknown to the writer was suggested apparently as early as 1812.

ROACHES, COCKROACHES, CROTON BUGS.

Ectobia (Phyllodromia) germanica.

This offensive household pest, almost world-wide in its distribution, so common in large cities, and known under the names given above, needs no special description. Families living in flats perhaps are greater sufferers than others, because no mat-

Fig. 49.—*Blatta germanica;* (a) first stage; (b) second stage; (c) third stage; (d) fourth stage; (e) adult; (f) adult female with egg case; (g) egg case enlarged; (h) adult with wings spread. All natural size except g. From "Household Insects," published by U. S. States Div. of Entomology.

ter how energetic one occupant may be in his efforts to exterminate the pest, if the other families in the flat make no attempts in this direction, the Roaches soon return to their old quarters. Many repellant poisons have been suggested, but this particular species seem very wary of poisoned baits. Undoubtedly the most

effective remedy is treatment with hydrocyanic gas, but this is so dangerous an agent, being fatally poisonous to human beings, that the Entomologist would only advise its use under most extreme precautions. Cir. 46, Second Series from the United States Department of Agriculture, Division of Entomology, describes this process in detail. Another gas, also poisonous, but not so deadly, bisulphide of carbon, can be effectively used where the insect infests small rooms which may be completely sealed. An Italian worker says that one part of the liquid bisulphide to every 10,000 parts of atmosphere, will kill all and every insect the gas comes in contact with. The writer has practically corroborated this in some work, as yet unpublished; but it should be noted that to do this the liquid must be of the best quality, and not the cheapest grade, which leaves a residue upon evaporation.

The Department of Agriculture recommends one part of bisulphide to every 1,000 cubic feet of room space to kill Roaches.

Another remedy suggested is burning Pyrethrum in a closed room. The writer has used a phosphorous paste with fairly good results, placing small bits of the paste about the sink in the kitchen and other places frequented by this pest.

Firms which sell bakers' supplies generally carry in stock a patent powder, said to be extremely effective in this direction. A family known to the Entomologist have driven Roaches away or exterminated them by the persistent use of powdered borax in the kitchen. This was dusted in all cracks and crevices about the room daily (particularly in the evening) for two weeks, care being taken to use it liberally along the entire length of mop board wherever there was a crack large enough to hide a Roach, and its use was persisted in for some time after all insects had apparently disappeared.

This insect at one time was called *Blatta germanica;* see Fig. 49.

CARPET BEETLES, CARPET MOTHS, BUFFALO MOTHS.

Anthrenus scrophulariae, Linn.
Attagenus piceus, Oliv.

Specimens of both the above carpet pests have been sent to

me during the past season, and I heard many complaints of Buffalo Bugs from housekeepers. Both of the above species were introduced from Europe, the former about 1874, and the latter as late as 1854, though it was not until 1879 that Dr. Lintner reported the latter as a carpet pest in connection with the first

Fig. 50.—Carpet Beetle, *A. scrophulariae*, and its work, showing beetle, larva, moulted skins of larvae and excrement, enlarged. Original.

named. Though their food habit may vary slightly in different localities, they both somewhere feed upon carpets, and remedies for both may be discussed under one head. It is well to note that many or most of the remedial and protective measures may also be used against the various species of clothes moth. In the adult state Carpet Beetles are found upon flowers. In addition to

Fig. 50, an excellent drawing (Fig. 61) of this pest will be found on page 69 of this report.

REMEDIES AND PREVENTIVE MEASURES.

Midsummer house cleaning of infested houses (we mention such a deviation from the old prescribed custom with fear and trembling), or two house cleanings each year (and from the man's standpoint this is a very unpleasant thought) is desirable, and should be most thoroughly attended to. If carpets are used they should be thoroughly beaten, and, if possible, sprayed out of doors with some such liquid as benzine or gasoline, and well aired afterwards. Rooms should have their bare floors thoroughly swept, washed with hot soap suds, and all cracks dusted with kerosene or benzine. If possible, it is desirable in bad cases to lay tarred paper on the floor before laying down the carpet. Should the carpet show any spots at any time during the year after such a treatment, affording evidence of the pest, we are advised by the United States Department of Agriculture to lay a damp cloth smoothly over the places affected, and iron with a hot iron, thus creating steam which will pass through the carpet and kill all insects below. The use of rugs on bare floors, or even rugs upon matting, is preferable to the use of carpets, for obvious reasons. In protecting furs and feathered goods and woolens from the ravages of these pests, one should proceed in the same way as in the case of protection from insect moths, viz. storing in tight chests or closets, with a supply of Camphor or Naphthaline balls, and frequent examination during the summer months. Chests lined with tarred paper, which paper is to be replenished each season, are useful.

It must be borne in mind that neither Camphor, Naphtha nor tarred paper kill the insects or their eggs, hence these must be eliminated before storing the goods. Where one can have access to cold storage woolens and fur can be protected, for none of these pests work in a temperature below 40 deg. Fah. Frequent beatings of furs, furniture cushions, woolens, etc., during the spring and summer, say in May, June, July and August, in this climate, would be of material help in case of such goods as cannot be well stored. Bisulphide of carbon affords a ready means

of killing these pests in a confined space; the writer has used it and has heard of its successful use elsewhere. A saucerful of this agent placed upon the top of woolens in a tight chest or trunk twice or thrice during the season, and allowed to evaporate during 24 or 30 hours, will invariably kill all insects in such chest or trunk. The liquid volatilizing and the heavy gas sinking through the fabrics, carries death as it goes. This liquid and gas is extremely inflammable. Housekeepers need no caution in this direction as regards Benzine and Gasoline, for all are aware of these qualities in the two latter agents.

The excellent practice of storing woolens and furs which have been thoroughly freed from eggs and from larva of these pests, in paste-board boxes, which are afterwards throughly sealed by pasting paper over the cracks, is well known.

BLISTER BEETLES ON WINDSOR BEANS.

Macrobasis unicolor, Kirby.

Windsor Beans upon the University farm were attacked this year by numbers of these beetles. They fed upon both the flowers

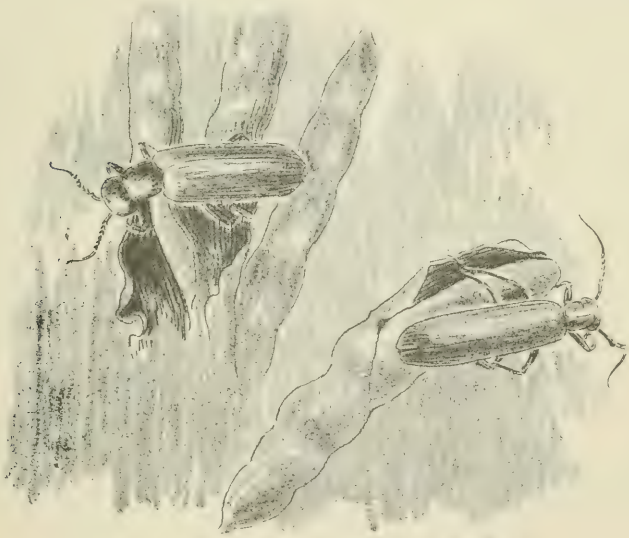

Fig. 51.—*Macrobasis unicolor* injuring beans.

and leaves. These insects can be controlled by several applications of Paris Green, dusted dry or sprinkled on the plant in liquid form. When Paris Green is used in water, take two tablespoonfuls of the poison to one pailful of water. If a quart of lime water or milk of lime is added to the water it will further insure the safety of the foliage.

The family *Meloidae* to which these Beetles belong has a curious characteristic, viz., although the adults are destructive to plants their young, hatching from the eggs laid in the ground, feed upon destructive insects or their eggs.

The species under discussion *M. unicolor,* is very active as a larva in eating the eggs of grasshoppers, and this fact should bid us pause before destroying the adults, unless the injury caused by them is very serious.

THE PLUM GOUGER.

Coccotorus scutellaris, Lec.

This Snout Beetle is probably the worst enemy of the fruit raiser in Minnesota, not excepting the Plum *Curculio.*

In September specimens were received from Luverne, with the statement that they had gathered upon the outside of sacks which had been filled with plums. The above picture, from a report of the late Prof. Lugger, illustrates this species very well.

The Plum Gouger is a reddish brown Beetle, with peculiar minute tufts of hair on its upper surface. The Beetle not only punctures the formed fruit, but also the ovary of the flower before the petals form. The egg-laying is a curious process, a round hole being made in the fruit into which a single egg is dropped. This is practically true of all the members of this great group of Snout Beetles, containing nearly or quite 25,000 known species, the beak, in the female at least, being used to prepare a place for the egg, and sometimes to push it to the bottom of the hole. The puncture soon heals, closing in the egg. Unlike the Plum Curculio, this Beetle larva feeds not only upon the flesh of the plum, but bores into the pit and eats the kernel. It changes to a Beetle in time to seek winter quarters near by. Plums which drop prematurely as a result of this injury should be collected and destroyed. From the fact that the grub is en-

closed in the fruit there is no use in spraying; this is on the assumption that this species always puts its egg into the fruit Forcibly jarring the tree early in the morning is advised, catching the beetles which fall on a sheet or similar contrivance, and burning them. The trees will have to be struck quite forcibly in order to dislodge the beetles. The gathering and burning of all

Fig. 52.—*Coccotorus scutellaris* Lec. Lugger.

rubbish about the orchard will, by destroying some of the places used for winter quarters, tend to reduce its numbers.

Note: Wherever in this report a line is found by the side of the picture of an insect, it denotes the actual size of the insect figured.

THE TARNISHED PLANT BUG.

Lygus pratensis, Linn.

Specimens of this insect were sent me May 7, 1902, from

Fig. 53.—The Tarnished Plant Bug (*Lygus pratensis*); four pinned speciments enlarged three times.

Brooklyn Center, with the statement that they were injuring the

Fig. 54.—*Lygus pratensis* Linn. Much enlarged. Lugger.

Currants (blossoms, petals and leaves) plum trees, flowering

shrubs, and to some extent, the ash trees. On May 16th the party wrote again that they "had nearly all left the currants"; on June 5th they were reported as "having gone," and the statement was also made, "we will only get one-third of a crop of currants."

This insect frequently causes both petals and leaves to wither and fall, sometimes killing the branch on which they occur. One can take advantage of its sluggishness early in the morning, and shake them from the bushes at that time onto sheets placed below, and then destroy them. Since they become very active as soon as they are warmed up by the sun, gathering them in this way is confined to the early morning.

They are reported as injuring many kinds of fruit beside currants, viz., strawberries, plums, apples, quince and cherries. The injury caused is not protracted; that is, its attacks are not lasting. It measures about one-fifth of an inch in length, and resembles the pictures accompanying this article.

THE MELON APHIS.

Aphis cucumeris, Forbes.

These lice attacked melons and cucumbers on the farm of George Jacobson, Luverne, Minn. Various remedial measures are mentioned for this pest, none of them easy of application when a large field is to be treated. Spraying the underside of leaves with kerosene emulsion, one part to twelve parts of water, or dusting Pyrethrum with a bellows onto the underside of leaves are both suggested. More reasonable, however, is the suggestion to destroy all the old vines and rubbish on the melon patch, and plant some crop other than melons or cucumbers there the following season. Frequently the attacks of this pest are not of long duration, the plant yielding a crop in spite of the visitation; parasites, too, kill many of them.

CORN LOUSE.

Aphis maidis, Fitch.

Another pest found in the State difficult to combat. There

is a root form and a branch form of this Louse. No artificial remedies are practicable.

The Entomologist would suggest rotation of crops; also feeding affected stalks to stock before the Aphis has laid its eggs.

Fig. 55.—Corn Plant Louse, much enlarged.

For garden corn, kerosene emulsion, one part to twelve, will readily relieve the trouble.

The Corn Louse is said to winter in the ground, and to produce wingless generations on the roots. The farmer is urged not to plant corn on the same ground two years in succession if he is much troubled by this insect. This, of course, means rotation of crops, as suggested above.

THE NEW YORK WEEVIL.

Ithycerus noveboracensis, Forster.

Specimens of this large snout beetle have been received this summer with statement that they were injuring apple and plum trees.

The Beetle is about two-thirds of an inch long, gray, with small black spots and white lines on its back. It is extremely destructive, feeding upon various kinds of fruit trees, but particularly upon plum trees in the spring, in May or June, eating

Fig. 56.—*Ithycerus noveboracensis* Forst., eating bark and leaves of plum. Lugger.

buds, leaves and twigs. The egg it is said, is deposited in a hole made in the bark by the female. It is evident that remedial measures are most advantageously applied before the eggs are laid. It is therefore suggested that as soon as the Beetles are observed they be destroyed by frequent jarring, catching them on a sheet or white cloth beneath the tree, and destroying them. As an auxiliary to this leaves and trees may be poisoned with Paris Green, using the same proportions with lime as recommended in discussion of "Blister Beetles on Windsor Beans." Fig. 62, on page 69, also represents this beetle.

Other injurious insects occurring during the past season were as follows:

Scolytids, on box elders.

Various Jassids, or "Leaf Hoppers."

A number of scale insects, various forms of plant lice, the usual quota of Cabbage Worms; a Mite, on box elders.

Ptinus fur on sacks of flour stored in elevator.

Tribolium confusum, in flour.

An *Anthomyd* causing the death of crop beans by boring in the stalk.

Box Elder Bug (*Leptocorisa trivittata);* a very few reported in Meeker and Big Stone counties.

The borer known as *Saperda cretata; Lyctus striatus* boring in timber, etc.

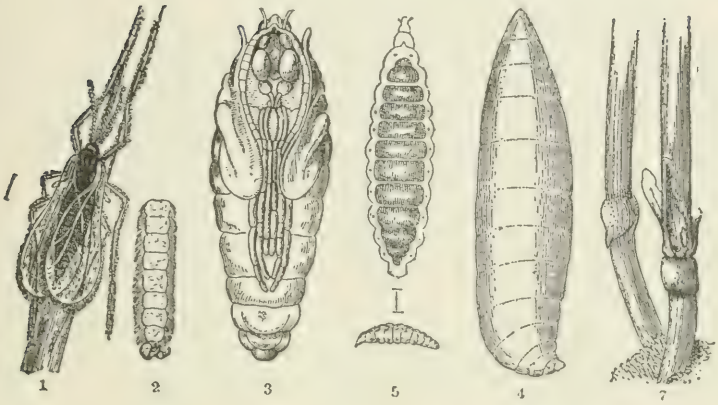

Fig. 57.—Hessian-fly: (1) adult female; (2) abdomen of male; (3) pupa removed from puparium (flax-seed); (4) puparium; (5) larvae; (7) puparia in position. All enlarged excepting 1. (After Taschenburg).

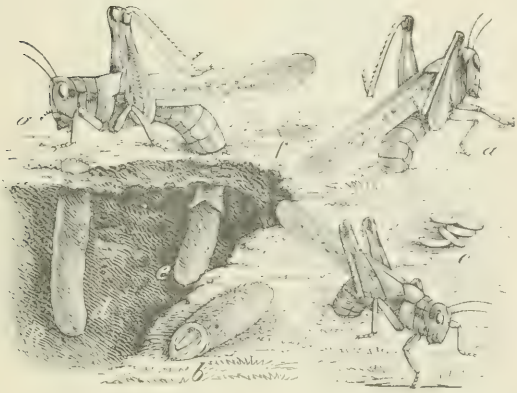

Fig. 58.—Rocky Mountain Locust: (a, a, a) female in different positions, ovipositing; (b) egg pod extracted from ground, with end broken open; (c) a few eggs lying loose on the ground; (d, e) show the earth partially removed, to illustrate an egg-mass already on place, and one being placed; (f) shows where such a mass has been covered up. (After Riley.)

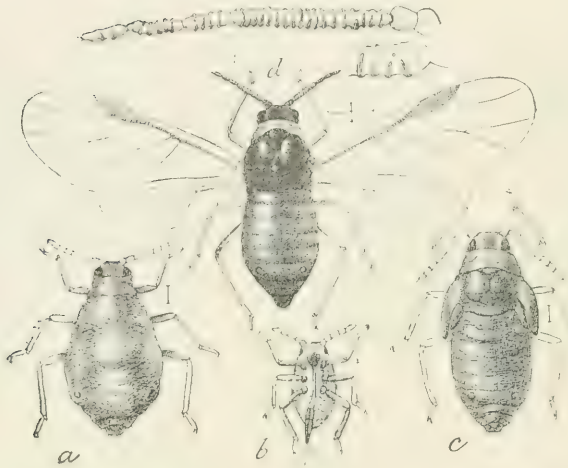

Fig. 59.—Woolly aphis (*Schizoneura lanigera* Hausm.)—(a) agamic female; (b) larval louse; (c) pupa; (d) winged female with antenna enlarged above; all greatly enlarged and with waxy excretion removed. After Marlatt, Division of Entomology, Dept. of Agriculture.

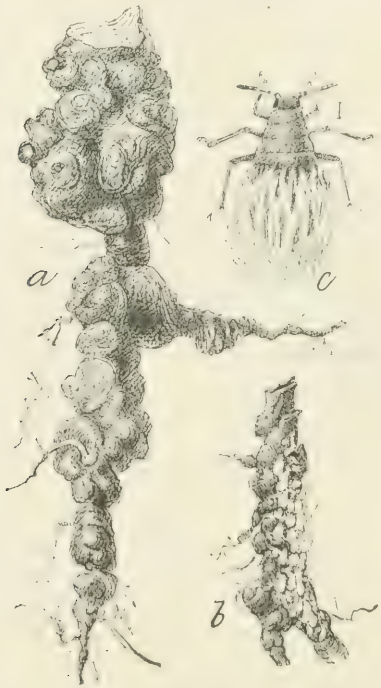

Fig. 60.—Woolly aphis.—(a) root of young tree illustrating deformation; (b) section of root with aphides clustered over it; (c) root louse, female; (a and b) natural size; (c) much enlarged. After Marlatt, Division of Entomology, Dep. of Agriculture.

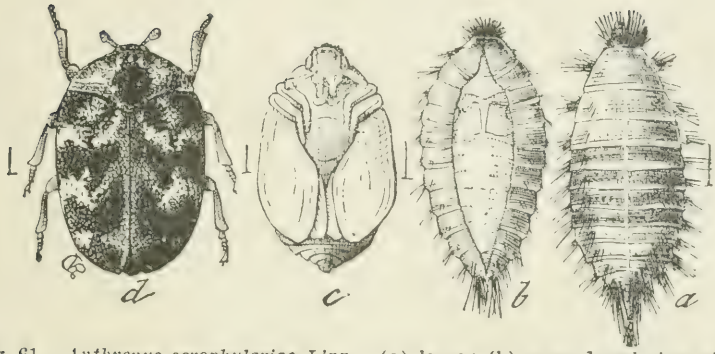

Fig. 61.—*Anthrenus scrophulariae*, Linn.—(a) larva; (b) pupa, dorsal view with split larva skin surrounding; (c) pupa, ventral view removed from skin; (d) beetle—hair lines showing natural size (after Riley).

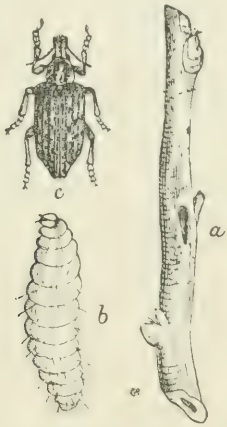

Fig. 62.—*Ithycerus noveboracensis* Forst.—(a) hole made with her jaws by female for insertion of her egg; (b) larva; (c) adult.

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EXPERIMENTS IN SHEEP HUSBANDRY.

THOMAS SHAW.

This bulletin contains two experiments. The first of these relates to changing the breeding habit in sheep, and the second to pasturing wethers with and without grain.

SECTION NO. 1.

CHANGING THE BREEDING HABIT IN SHEEP.

In some of the large cities of the East a considerable demand is springing up for, what is commonly termed, winter lambs, although the term hot-house lambs has also been applied. They are called winter lambs because they are put upon the market at that season, although not yet weaned. And they are called hot house lambs, because they are reared under what may be termed forcing conditions, and under conditions of protection more complete than those which usually apply to lambs. The latter term, however, is something of a misnomer, as, in growing them, the conditions as to temperature do not of necessity require to be much warmer than those suitable for other lambs. Winter lambs may be dropped at any time from October to the end of January or February, and they are usually ready for the market at the age of 60 to 90 days. At that age they should weigh from 50 to 60 pounds, if they and their dams have been properly fed.

Advantages in Growing Winter Lambs.—The advantage in growing such lambs lies, first, in the relatively high price which they bring at a season of the year when such meat is regarded as a delicacy; second, in the fact that the labor of growing them comes at a season when labor is not so valuable as at others seasons; third, in providing a source of revenue at a time when the labor does not ordinarily interfere with the work of the farm, and fourth, in making it easily possible to dispose of the dams at a good price because of the season at which they may be marketed. The price for such lambs usually runs from 10 cents upward per pound,

live weight, when they are marketed with promptness and in an intelligent way. As the ewes must be fed freely while suckling their lambs, they are in that condition as to flesh and the ability to take on flesh rapidly when the lambs usually are weaned, which, in a short time makes them ready for the block if it should be desired to dispose of them thus. At such a time the price is usually higher that at other seasons of the year.

The Industry is Comparatively New.—Not many years have elapsed since winter lambs began to be grown in this country. It is making rapid strides however, particularly in the Eastern and in some of the middle states. The demand for such meat, which is in a sense a luxury, comes from cities where wealth has accumulated. The cities of New York, Boston and Philadelphia are chief among these, but the demand is rapidly extending to the large cities of the Lake regions and to those of the Mississippi basin. It is fair to infer, therefore, that winter lamb will soon be a regularly appearing commodity in all the great cities of the United States.

Who Should Grow Winter Lambs.—Those only should attempt to grow winter lambs who are so located that they can ship them readily. They ought to be near a railroad station, and should be within easy reach of telegraph and telephone communication, in order to readily supply customers as they forward orders. They should also be so situated that they can grow and store a sufficient supply of field roots and other foods suitable for ewes and dams. And they should have ample shed room and divisions in their sheds to admit of feeding ewes and lambs in groups or lots, according to the special needs of each. Moreover, they should have one or more lambing pens, at least, reasonably warm.

Difficulties to be Overcome.—The chief difficulties to be overcome in the meantime in this Western country are, first, the scarcity of the materials from which such lambs can be bred, and second, the opening of suitable markets in the West. The first named difficulty arises from the fact that only two breeds have the property of dropping winter lambs at the season of the year desired. These are the Dorsets and

the Tunis. The latter are not numerous as yet in the United States, nor is the habit of producing such lambs so pronounced in them as in the Dorset. So few in numbers are the Tunis in the United States, that it would seem scarcely necessary to consider them a factor in the present discussion. The Dorsets have increased with great rapidity in this country, but in the pure form they are too dear for one to invest in Dorset females for the sole purpose of furnishing winter lambs for the block. Ewes that cost less money would seem to be a necessity to induce farmers to engage in this work. The hope of obtaining such material led to the experiment outlined in this bulletin. The other difficulty may be expected to adjust itself in time. With a supply of such a commodity properly furnished, the demand may be expected to come from cities not far distant.

Time Covered by the Experiment.—The experiment began in the summer of 1895 and it continued until the Autumn of 1901, thus covering a period of 6 years. But, as previously stated, it was not conducted with that orderly sequence that could have been desired. For instance, the number of the dams kept over from year to year was not always the same, nor was the proportion of the ewe lambs the same from year to year. It is impossible, therefore, to give the results of what could be regarded as a complete experiment. Nevertheless, the results obtained are from data sufficiently complete to furnish a reasonably safe basis on which to ground conclusions.

Objects of the Experiments.—The following were chief among the objects of the experiment: First—To ascertain whether the habit in common ewes of dropping lambs in the spring, could be so changed that they would drop them in the fall or early winter through successive matings with pure bred Dorset sires, accompanied by a close selection. Second—To learn, if possible, how many generations of breeding would be necessary before the habit became at all fixed in character. Third—To find out whether food played any important part in the change of the breeding habit, and if so, to glean information with reference to the same that would be turned to practical account. And fourth—To ascertain, whether, in the event of a change in the breeding habit hav-

ing been effected, it would not then be possible to mate the dams with sires of some of the other mutton breeds so as to improve mutton quality in the lambs. Among the minor objects were the following: First—To glean information with reference to the foods that could be used with the greatest advantage in feeding ewes and lambs under Minnesota conditions. And Second—To glean information with reference to marketing the lambs that could be turned to practical account. It should be stated here, however, that the congested condition of our sheep sheds during the major portion of the time, prevented us from carrying out the details of the experiment in that regular and exact way that would give the results, therefore, should be regarded as only close approximations to the truth.

Animals Used in the Experiment.—The ewes chosen for the experiment came from the flock of Mr. Hugh Paul, Dundee, Minn., and also from the ranges of Montana. In both instances they were simply common grade ewes of very mixed breeding. It would be impossible of course to be quite sure of all the blood elements in them, and of the proportions in which they preserved these. But, it would be safe to say, that in them was the blood of two or three of the dark faced breeds, more particularly the Shropshire and Oxford Down, also that of the Cotswolds or Lincolns, and of the American Merinos.

The presence of all these blood elements was not evidenced in each of the ewes individually, but the presence of some two or three or even more of them was evidenced in the make up of various individual females chosen for the work. Merino blood, as witnessed in the fleece, the wool on the head and the wrinkles in the skin, was the most pronouncedly in evidence. But two Dorset rams were used during the experiment. The first, Austin, No. 4554, lambed in December, 1893, was used during the first two years of the experiment. The second, Paso, No. 6700, lambed in 1896, was used during the remainder of the same. Both were good specimens of the breed, particularly the last mentioned.

General Plan of the Experiment.—The following plan was followed as closely as the circumstances would permit. The first summer the ewes were bred as soon as they would

mate. Subsequently, those of them that had produced lambs early were bred when practicable, while yet in the sheds, but subsequently to the disposal of their lambs. To hasten the time of mating, stimulating grain food such as barley and wheat, accompanied with a moderate supply of roots, was fed with some freedom to the ewes after they had been dried. In many instances, but not in all, ewes would mate within a short period after they had been fed thus. Subsequently to their being turned out on grazing, it was noticed that the ewes would not mate until a considerable period after leaving their winter quarters, and this, notwithstanding that the grain food was continued. This arose, probably, in part at least, from that reduction of the system which usually follows in a greater or less degree, when animals are turned into succulent grazing in the spring. In some instances, but not many, the ewes would mate too early in the season if allowed to do so. It was not considered desirable to have the lambs dropped before October 1st, as otherwise they become too large and heavy to take the market readily by the time that winter lambs are in demand. No attempt was made to breed them twice a year, as, under our conditions, there would seem to be no good reasons for thus taxing the powers of the ewes so severely, such breeding would be pretty certain to result in reduced stamina, and it would bring the second crop of lambs into the market at a time when the price of mutton is usually low.

In the winter the ewes were kept in sheds with small yards attached. Unless in extremely cold weather, both ewes and lambs had easy access to sheds and yards during the day. No attempt was made to keep the lambs any warmer than the other sheep of the flock, except from birth until they were a few days old. Both ewes and lambs were fed with much freedom until the latter were sold, but the ewe lambs to be retained for breeding were not as a rule pushed along so rapidly. Owing to local market conditions the lambs were not always marketed at the proper age. Some had reached too large a size and too old an age to command highest prices. In summer, the ewes and lambs retained for breeding were grazed on pastures other than

grass as shown below. The ewes that lambed late and also their lambs were discarded for breeding uses. The wether lambs not disposed of early, were usually fattened and sold the following winter.

Foods and Feeding.—Before dropping their lambs, the ewes were simply fed enough of such foods as were in season to keep them in a good condition of thrift. Afterwards they were fed lightly for a few days, but, from the time the lambs had reached the age of one week until they were sold, the ewes were fed most generously, and also the lambs from the time they would take food. The favorite grain food for the dams was oats and bran, in proportions about equal in measure. Of this they were given virtually what they would consume with a relish. Some corn was also added in nearly all instances, and some oilcake, less probably than 5 per cent of the latter. Good clover hay was the favorite fodder. Next to this was a mixture of peas and oats grown together, and third in order was corn. Some millet was fed, but it was not so keenly relished as the other fodders. Sometimes only one of these fodders could be fed at once. At other times two or three of them were fed. Field roots, usually mangels, but in some instances sugar beets and also carrots were fed with much freedom. In fact the ewes were given of these about all they would eat.

A creep was put in for the lambs as soon as they would take grain, which was usually about three weeks subsequently to the birth period. They were given bran and oats to begin with. Later, corn cracked and oilcake were added. The proportions of these foods were by bulk as follows:—Oats 3 parts, bran 3 and corn 1, and the oilcake was about 10 per cent or a little less than that of the whole mixture. They were given all that they would take of this mixture until they were sold. Roots were also given quite as freely as the grain, choice fodder was also given to the lambs until they became able to help themselves to fodder along with the ewes. The fodder was fed uncut. The grain was fed unground, except the corn, which was cracked for the lambs, and the roots were sliced for both ewes and lambs. Salt and water were accessible at all times, and much care was exercised in keeping the pens nicely bedded.

Ewes and Progeny.—Table I gives the ear No. of the respective ewes used in the experiment; the number of the cross or grade of each; the lambs produced by them, and the respective date at which the lambs were produced.

TABLE I.—Ewes, Progeny and Date of Birth of Progeny.

EWE		LAMBING. Winter '96–97.			LAMBING. Winter '97–98.			LAMBING. Winter '98–99.			LAMBING. Winter '99–'00.			LAMBING. Winter '00–'01.		
No.	Cross	Month	Day	No. & Sex	Month	Day	No. & Sex	Month	Day	No. & Sex	Month	Day	No. & Sex	Month	Day	No. & Sex
65	1st	Jan.	20	1 Ram	Jan.	8	1 Ewe	Dec.	24	1 Ewe	Feb.	4	1 Ewe 1 Ram			
271	1st	Nov.	26	1 Ewe	Oct.	30	Aborted	Oct.	8	1 Ram	Sept.	6	1 Ram	Feb.	20	2 Ewes
66	1st	Feb.	4	1 Ram 1 Ewe	Jan.	24	1 Ewe 1 Ram	Jan.	2	1 Ewe 1 Ram	Oct.	27	1 Ewe 1 Ram	Oct.	14	1 Ram
61	1st	Feb.	27	1 Ewe	Feb.	13	1 Ewe 1 Ram	Dec.	29	1 Ram	Jan.	7	2 Ewes	Dec.	27	2Rams
59	1st	Mar.	6	2 Ewes	Feb.	9	1 Ewe 1 Ram	Jan.	10	Died Lamb'g						
64	1st	Feb.	21	1 Ram	Feb.	16	Ruptured Killed									
268	1st	Jan.	30	1 Ram												
269	1st	Feb.	25	1 Ram												
272	2d				Dec.	20	1 Ewe 1 Ram	Jan.	5	1 Ewe 1 Ram	Dec	28	1 Ewe 1 Ram	Jan.	14	2Rams
273	2d				Oct.	12	1 Ewe 1 Ram	Jan.	14	2 Rams	Oct.	25	1 Ewe 1 Ram	Oct.	12	2Rams
275	2d				Dec.	30	1 Ewe									
317	2d				Jan.	19	1 Ram									
270	1st				Jan.	23	1 Ram	Dec.	24	2 Ewes	Jan.	23	2 Ewes			
274	2d				Jan.	25	1 Ram	Jan.	19	1 Ewe	Jan.	19	2 Ewes			
219	2d				Jan.	31	1 Ewe 1 Ram	Dec.	31	1 Ewe 1 Ram	Oct.	27	1 Ewe 1 Ram	Oct.	6	1 Ewe
211	2d				Jan.	31	2 Ewes									
255	2d				Feb.	5	2 Rams	Jan.	31	2 Ewes	Jan.	16	1 Ram	Dec.	21	1 Ewe 1 Ewe
79	1st				Feb.	12	1 Ewe 1 Ram	Jan.	16	1 Ewe	Feb.	4	1 Ewe 1 Ram	Feb.	17	1Ram
310	3rd							Oct.	9	1 Ewe	Sept.	1	1 Ewe	Jan.	11	1 Ewe 1 Ram
											Feb.	22	2 Ewes			
302	3rd							Jan.	2	1 Ewe	FATTENED					
313	2d							Jan.	14	1 Ewe				Mar.	6	1 Ram
298	2d							Jan.	14	1 Ewe	Jan.	24	2 Ewes	Jan.	23	1 Ram
312	2d							Jan.	2	1 Ram	FATTENED					
315	3rd							Jan.	7	1 Ewe						
300	3rd							Jan.	24	1 Ewe	Jan.	13	1 Ram	Jan.	15	1 Ram
267	1st							Feb.	4	1 Ewe 1 Ram	Jan.	22	2 Ewes	Jan.	15	2Rams
299	1st										Jan.	23	1 Ram	Jan.	29	1 Ram

It will be observed that, of the 27 ewes in the experiment but 12 were of the first cross, 11 of the second and but 3 of the third. The number of the third cross ewes would have been greater, but for the fact, that several of them kept over were devoted to other lines of breeding. In fact, the entire experiment was in a sense a side issue, as some of the animals of these respective crosses, not in the experiment proper, were from time to time used in other lines of experimenting. But those retained for the experiment were fairly representative.

Lambs Born in Certain Months.—Table II gives the dates at which lambs were born in certain months from ewes of the respective crosses.

TABLE II.—Months in which Lambs were Born.

Cross	Lambing. Winter '96-'97		Lambing. Winter '97-'98		Lambing. Winter '98-'99		Lambing. Winter '99-'00		Lambing. Winter '00-'01	
	Month	No.	Month	No.	Month	No.	Month	No.	Month	No.
1st	Nov.	1	Oct.	1	Oct.	1	Sept.	1	Oct.	1
	Jan.	2	Jan.	3	Dec.	2	Oct.	1	Dec.	1
	Feb.	4	Feb.	4	Jan.	2	Jan.	4	Feb.	2
	Mar.	1	Dec.	1			Feb.	2	Jan.	2
2d			Oct.	1	Dec.	2	Oct.	2	Oct.	1
			Dec.	2	Jan.	6	Dec.	1	Jan.	1
			Jan.	5			Jan.	4	Dec.	1
			Feb.	1					Mar.	1
3rd					Oct.	1	Sept.	1	Jan.	2
					Jan.	3	Jan.	1		
							Feb.	1		

The advance in the average period of earliness at which the lambs were dropped by the ewes of the second and third crosses, is not what should be looked for, but it is partly explained by the fact, that none of the ewes of any cross would mate for some time subsequently to the period when grazing began. This explains why scarcely any lambs were dropped during the month of November. More October lambs could have been obtained, had they been desired, from ewes of the

second and third crosses. Had the ewes been turned out on rich blue grass pastures, it may be that the results would have been different.

Disposal of the Lambs.—No attempt was made to sell the lambs in a special market for the same. The chief object of the experiment was to ascertain if they could be grown beginning with ewes of common and mixed blood. The numbers on hand were too limited to justify the attempt to establish a permanent market for such lambs in the Twin Cities, hence they were disposed of variously, and usually too late in the season to bring highest market prices.

In 1897 one ewe lamb was sold April 8th, to E. M. Prouty & Co., of South St. Paul. The age was 134 days, the weight 69 pounds, and the price paid was 16 cents per pound live weight, amounting to $11.04. The other ewe lambs were kept for breeding, and the lambs were fed under experiment the following winter.

In 1898, four lambs were sold to F. W. Luly, St. Paul, on April 6th. The average weight shrunk was 63¾ pounds. The price paid was 10 cents per pound, live weight, amounting to $6.37 on an average per lamb. The ewe lambs were kept for breeding and the other wether lambs were fed for experiment the following winter.

In 1899, six lambs were sold on March 31st, to J. H. McCormick, St. Paul. The average weight was 55⅓ pounds. The price paid was 10 cent per pound, live weight, amounting to $5.53 per lamb, on an average. The ewe lambs and the remaining wether lambs were used as stated the previous year.

In 1900, seven lambs were sent to Chicago, along with fat lambs of the previous year. Of these, five weighed on an average 70½ pounds, and brought 11 cents per pound, thus averaging $7.75 per lamb. The other two average 115 pounds, and being over-heavy sold for 9 cents per pound, thus averaging $10.35 per lamb. The other lambs of the same grade were used as in the previous year.

In 1901, eight lambs were delivered on May 16th, to Haas Bros., St. Paul. On May 30th, eighteen lambs were delivered to the same firm. The first averaged 45 pounds and the second lot 75 pounds. The price paid was $3.60 on

an average per lamb for the first lot, and $6.00 on an average for the second. The other lambs were used similarly to those kept in preceding years. In the meantime the process of eliminating the ewes that were least suitable for retaining went on from year to year.

Progeny of the Southdown Cross.—In the summer of 1900, several of the Dorset ewes were mated with a Southdown ram. The object was to get lambs that could be shown at the International Fair to be held in Chicago in December of the following year. From the progeny thus begotten seven lambs were selected to be fitted for the said show. Five of these were shown in the class for fat grade lambs and open to the world. They won first honors as best pen of five, and also for best single grade lamb in the exhibit. In the contest for best fat lambs, open to all the Agricultural Colleges on the Continent, they won first, second and third prizes. Four of the number were then slaughtered and shown in the dead meat class with the result that they won first and third prizes, competing against the world. They also formed part of the exhibit from the Minnesota Experiment Station, which won first prize for the best exhibit of the show in the dead class.

The mutton form of the grade lambs of this cross was superior to that of lambs from the pure Dorset sires and they were also more easily kept in a good condition of flesh.

CONCLUSIONS.

The following are the more important of the conclusions based upon the results from the above experiment:

1. That the breeding habit in ewes which usually drop lambs in the spring may be so changed that they will produce them in the fall and early winter.

2. That this change can be effected sufficiently for practical uses in from two to three generations of judicious crossing when accompanied by a judicious selection.

3. That it may be effected thus quickly by choosing very common ewes of mixed breeding, and mating them with pure bred Dorset rams, always reserving the earlier dropped lambs for breeding uses.

4. That in the transforming process, the dams which have suckled winter lambs may usually be bred more readily

before being turned out on grass than subsequently, and especially when fed a stimulating grain portion while yet in the sheds.

5. That when the change sought has been thus effected in the dams, a superior quality in the lambs may be obtained by using rams in service of certain of the dark-faced types and more especially of the Southdown and Shropshire breeds.

6. That such foods as clover hay, and corn fodder, bran, oats. barley, corn and oilcake, also fields roots prove very satisfactory under Minnesota conditions for the production of such mutton in winter.

7. That in the markets of the West the demand for such lambs is not yet so good relatively as in certain markets further East.

Section No. 2.

PASTURING WETHERS WITH AND WITHOUT GRAIN.

The keeping of sheep chiefly on pastures sown for them is of but recent introduction in America. As far as known to the writer it was first practiced at the Minnesota University Experment Station in 1895. Since that time the principle involved has become incorporated more or less into the practice of many of the flockmasters of the country. It has been found that even the partial practice of such a system promises to revolutionize the methods of keeping sheep in the United States. The following are chief among the benefits flowing from it: First—It enables the flockmaster to maintain a much larger number of animals than he could otherwise. Second—It makes it possible for him to give them more or less of succulent pasture from spring until fall, which is favorable to their development. Third—It makes it possible for him to destroy nearly all forms of weed life, and cheaper and more effectively than it can be done in any other way, and Fourth—It enables him to fertilize his land so that it shall be in a good condition to grow other crops, particularly grain crops without anyother fertilizing.

While experimenting thus in growing pastures, the thought came up in the mind of the writer as to whether it would pay to add grain to the pasture, especially when the

object was to fatten the sheep while being thus grazed. Some experimenting had been done in that line in Ontario when conducting the Agricultural department of that Station, but it related to feeding grain on fall rather than on summer pastures. This experiment was undertaken for the purpose of throwing light upon this question, and it is the only one of the kind up to the date of the experiment which the writer can recall.

Plan of the Experiment.—The plan in a general way included the securing of two lots of wethers and pasturing them until they should be in condition for the block. They were to be put on grazing as soon as it should become plentiful. The grazing was to consist of crops sown for this purpose other than grass, and in a succession such as would provide food for them in a seasonable condition. This means grazing which would be eaten by the animals when in that condition which would cause them to eat it with a relish, and when it would be sufficiently plentiful to satisfy their appetites. One lot was to be given one-half pound each per day of oats during the experiment proper. The other lot was to have no grain supplement. When the experiment proper ceased it was proposed to pasture them for some time subsequently, that their behavior at such a time might be noted and studied.

The Time Covered by the Experiment.—The experiment proper began May 2nd, 1899, and extended to August 21st following. It was divided into four periods of 28 days each, and therefore covered in all 112 days. But the subsequent behavior of the sheep was noted until about the close of the grazing season.

The Object of the Experiment.—Chief among the objects of the experiment were to ascertain: First—The relative increase made by sheep on spring and summer grazing with and without a small grain supplement. Second—The relative return, if any, obtained from feeding the grain. Third—The relative condition of the animals as to flesh at the close of the experiment proper, and Fourth—The behavior of the two lots while on grazing during the remainder of the grazing season.

The Animals Chosen.—The animals chosen were wethers.

They were purchased at the the New Brighton Stock Yards, from Mr. Kenneth McLean, of Miles City, Montana. They were purchased in the Autumn of 1898, were brought to the Station and wintered on moderate fare. They were not given much grain during the winter season. They were in a fair condition as to thrift when the experiment began. They were lambs reared on the range. They were possessed of a Merino foundation, and had more or less of Down blood, as indicated in the more or less of dark shading of the face and legs. They were what may be termed a fairly good type of range wethers.

The Pastures Grazed.—The following were the pastures grazed and the respective dates of grazing them:

Winter Rye	May 2nd to May 29th
Peas and Oats	May 29th to June 26th
Barley and Oats	June 27th to July 5th
Rape and Kale	July 6th to Aug. 13th
Rape	Aug. 13th to Aug. 17th
Peas and Oats	Aug. 17th to Aug. 26th

Winter rye was first in season. It, of course, had been sown in the fall, and the wethers were turned on it to graze almost as soon as it had become plentiful. The peas and oats and barley and oats were sown early in the spring. All the grains were sown at the rate of about 2½ bushels per acre. The rape and Kale were sown broadcast, reasonably early in the season, and at the rate of 5 pounds of the seed per acre. The peas and oats last mentioned were of second growth.

Management of the Wethers.—The wethers were turned in to graze on the same kinds of food morning and afternoon. They were given the shelter of the sheep shed during the heat of the day. But they were not given darkened apartments in the shed, which would doubtless have been to their advantage in the time of flies. They also lay in the yards of the shed at night. Both lots had free access to water in the sheds and also to salt. The wethers comprised two lots with ten animals in each lot. One of these designated lot 1 were not given any grain during the experiment. The other lot were given one-half pound each of a supplement of oats daily, during the continuance of the experiment. The wethers were weighed at the end of each period.

Weights of the Wethers.—Table III gives the aggregate

weights of the wethers in each lot when the experiment began and ended, the total increase made, and the averages of these.

TABLE III.—Weights and Increase.

LOT		WEIGHTS WHEN EXPERIMENT. Began May 2nd.	Closed Aug. 21st	INCREASE
1	Total	805.0	973.0	168.0
	Average	80.5	97.3	16.8
2	Total	809.0	1078.0	269.0
	Average	80.9	107.8	26.9

The increase made was not very large by the wethers of either lot, but it was very much better in the case of the wethers to which grain was fed. Those in lot one made a gain of only 16.6 pounds each, or at the rate of but 4.5 pounds per month of 30 days. Those in lot two made a gain of 26.9 pounds, or 7.2 pounds per month. These gains were, however, all that could be reasonably looked for at that season of the year, especially under the conditions. In hot weather and when flies are plentiful, sheep will not make the gains that they do in the fall.

Table IV, gives the increase made by the wethers of each lot during each period of the experiment, and the averages of such increase.

TABLE IV.—Increase by Periods.

LOT		GAINS BY PERIODS. First	Second	Third	Fourth	Total
		May 2—May 29	June 26	July 24	Aug. 21.	
1	Total	24.0	26.0	23.0	95.0	168.0
	Average	2.4	2.6	2.3	9.5	16.8
2	Total	71.0	54.0	33.0	111.0	269.0
	Average	7.1	5.4	3.3	11.1	26.9

It will be noticed that during the first period while the wethers were pasturing on rye, those in lot two made practically three times the increase made by the wethers in lot one. This is what should be looked for under such conditions. During the second period, when the pasture was chiefly peas and oats, the lambs in lot two gained more than twice as much as the lambs in lot one. During the third period, neither lot made the increase that was to be expected. It may be accounted for in part, by the less advanced condition of the rape as compared with the same during the following period, in part by the nature of the wethers, and possibly in part by the variations in the weights of animals which are known to occur from day to day. The gains made during the fourth period were excellent in the wethers of both lots.

After the close of the experiment proper the wethers in lot one were also given a grain portion of ½ pound each of oats per day and the same grain supplement was continued with the wethers in lot two. The grazing was also continued until Nov. 6th, that is to say, it was made to cover 77 days, or two periods of 28 days each and a third period of 21 days. From Sept. 14th to Oct. 18th the pasture was cabbage, and from Oct. 18th to Nov. 6th it was rape.

Table V shows the increase made by the lambs of both lots during the experiment proper, and also during the subsequence grazing.

TABLE V.—Gains by Periods During the Entire Experiment.

	GAINS BY PERIODS.								
LOT		1st	2d	3rd	4th	5th	6th	7th	Total
		May 2—May 29	June 26	July 24	Aug. 21	Sept. 18	Oct. 16	Nov. 6.	
1	Total	24.0	26.0	23.0	95.0	6.0	89.0	17.0	280.0
	Average	2.4	2.6	2.3	9.5	.6	8.9	1.7	28.0
2	Total	71.0	54.0	33.0	111.0	2.0	60.0	20.0	341.0
	Average	7.1	5.4	3.3	11.1	.2	5.0	2.0	34.1

It will be noticed, first, that the relative increase was reversed during the after experiment, that is, during the subsequent period of grazing. In the 112 days of the experiment proper the wethers in lot two made an aggregate increase of 269 pounds or 7.2 pounds per month of 30 days and the wethers in lot one made an aggregate increase of 168 pounds or but 4.5 pounds per month. In other words the wethers in lot two gained 60 per cent more than the wethers in lot one. In the 77 days of the continuance of the after experiment the wethers in lot one made a gain of 112 pounds or 4.4 pounds per month of 30 days. While the wethers in lot two gained but 72 pounds or 2.8 pounds per month. In other words the wethers in lot one increased 50 per cent more than the wethers in lot two. Second, the increase during the fifth period of very hot weather is so slight as to be scarcely worth mentioning, and third, the increase during the last period was also small, owing to the fact probably that the wethers had reached that point when rapid gains could not be incurred without feeding grain heavily.

Cost of Increase.—The cost of increase cannot be accurately ascertained owing to the difficulty of properly valuing the pasture consumed, but the result from feeding grain to the lambs in lot two can be ascertained at least approximately. During the experiment proper, the wethers in lot two consumed 560 pounds of oats which at 21 cents per bushel, the market value at the time, amounts to $3.69. As they gained 101 pounds more than the wethers in lot one, the cost of making 101 pounds extra of increase was $3.63, and this cost would probably be still further reduced by some saving effected in the consumption of pasture, because of the grain fed. This, however, could not be certainly ascertained, as under the circumstances there was no means of determining the relative amount of pasture consumed by the wethers of either lot. Since, however, the cost of the extra increase made by the wethers in lot two was less than the market value of the same at the time, and since the wethers in this lot were in a better condition for marketing at the close of the experiment proper than those of lot one.

It is very evident that the small grain supplement fed was a paying investment.

CONCLUSIONS.

The following are chief among the conclusions that may be shown from the experiment:

1. That in this experiment, during the 112 days of its continuance, the wethers in lot two which were given a grain ration of ½ pound oats each per day, gained 60 per cent more than the lambs in lot one which were given no grain.

2. That, during the experiment proper the extra increase made by the wethers was worth more than the cost of the grain used in making it.

3. That the wethers in lot two were in a better condition of flesh at the close of the experiment proper than those of lot one, and consequently if marketed at that time would have sold for a better price.

4. That since the wethers in lot two gained 60 per cent more than those in lot one during the 112 days of the experiment proper, and since the wethers in lot one gained 55 per cent more than those in lot two during the 77 days of the after experiment, the conclusion would seem to be legitimate that the power of a grain supplement such as that used in the experiment to produce increase lessons after it has been fed for several months.

5. That feeding a small grain supplement of oats to wethers that are being grazed is profitable for a period of several months after which it becomes less profitable, if indeed, profitable to any extent.

INVESTIGATION IN MILK PRODUCTION.

T. L. HÆCKER.

1. THE FOOD OF MAINTENANCE.

In all living bodies there is a constant breaking down of tissues or wear, caused by every muscular action, just as is the case with any piece of machinery. There is also energy expended in the action of the muscles and body heat must be maintained. The nutrients used by an animal in keeping intact the body, that is, in rebuilding the portions worn out and in providing the energy and maintaining body heat when at rest in stall, is termed the Food of Maintenance or Food of Support. The generally accepted feeding standard, Wolff's, gives 18 pounds of dry matter and of nutrients, .7 of a pound of crude protein, 8 pounds of carbohydrates and .1 of a pound of ether extract or fat, as the amount needed daily for maintenance per thousand pounds live weight.

During our earlier feeding experiments it was observed that in some instances cows did fairly good work in the dairy during a whole winter on only a trifle more feed than that prescribed for food of maintenance, indicating that the amount fixed by the standard in general use was in excess of the actual requirements. Sanborn of the New Hampshire station reported in 1879 that the steer could be maintained on a smaller allowance of hay than is prescribed in the standard. Caldwell, of the Cornell Experiment Station, New York, reports a trial where four steers gained 180 pounds during a period of 60 days, on practically a maintenance ration. Kuehn, a German investigator, in experiments extending over several years showed that the mature bovine could be maintained on .7 of a pound of protein and 6.6 pounds of nitrogen free extract, and that whatever was fed in excess of this amount, caused gain in weight at the rate of from 20 to 25 per cent of the amount so in excess. It was evident therefore that at the time when the dairy division of the University of Minnesota was established, there had been

enough data obtained to show that there was still a question as to the nutrients actually required for food of maintenance. It was evident then that in a series of experiments in milk production, which would be likely to extend over two decades, more information ought to be secured as to food required for maintenance under conditions obtaining in the Northwest. It was not possible with the limited and inadequate facilities accorded the dairy division in securing the composition of food stuffs and feces to carry on the work from a purely scientific standpoint, nor was it considered advisable to do so. The work has therefore been carried on from the more practical phase in the belief that in this form it would receive more attention from milk producers than would be the case if given in more elaborate and technical form.

A mere preliminary trial on a maintenance ration was begun on the 31st of October, 1894, when two barren dry cows were fed on a daily ration of 10 pounds of timothy hay and 3 pounds of ground barley for a period of 81 days. Their weight at the beginning of the trial was 1676 pounds, and at the close, 1735 pounds, being a gain of 59 pounds, or .36 of a pound each per day. The average weight of the cows during the experiment was 853 pounds. The dry matter and nutrients of the ration per 1,000 pounds were as follows:

TABLE VI.—Giving Food and Nutrients Consumed Daily.

	Lbs.	D. M.	Digestible Nutrients		
			Protein	Carbohydrates	Ether Extract
Timothy Hay	10	8.768	.318	4.509	.18
Barley Meal	3	2.646	.283	1.792	.06
Total		11.414	.601	6.301	.24
Per 1000 lbs. live weight		13.38	.704	7.386	.28

It is shown by the above table that the ration fed was practically the amount prescribed in the Wolff standard, but contained .614 of a pound less of carbohydrates and .18 of

a pound more ether extract. Reducing the .18 of a pound of ether extract to a carbohydrate equivalent (.18 x 2.25) .405 of a pound and adding this to 7.386, the carbohydrates for convenience in comparing the ration fed with the Wolff standard, we have the following:

TABLE VII.—Giving Nutrients Consumed Daily and the Wolff Standard.

	D. M.	Digestible Nutrients		
		Protein	Carbohydrates	Ether Extract
Ration fed per 1000 lbs. live weight...	13 38	.704	7.791	.10
Wolff Standard maintenance ration ...	18.00	.70	8 00	.10

The ration fed provided, practically, the amount of protein called for by the Wolff standard and .209 of a pound less of non-nitrogenous matter, and produced a daily average gain of .36 of a pound, showing that the ration fed was in excess of the amount actually needed for food of maintenance.

The second experiment was conducted with two barren dry cows during the winter of 1896–97 covering a period of 100 days. One received 18 pounds and the other 14 pounds of fodder corn daily. The following gives their weight at the beginning of the trial and at the close, being the average of daily weighings which were in all cases made in the morning after feeding and before watering, and the average of all their weights during the trial:

	Alice.	Belle.
Weight at beginning.....	797	1005
Weight at close.....	803	985
Average weight.....	808	1010

At no time after the first 11 days did Alice fall below 800 pounds and Belle maintained a weight above 1000 pounds until the month of February when her average weight was 987. The dry matter consumed daily and nutrients digested, as determined by a digestion experiment during the trial, is given in the following:

TABLE VIII.—Dry Matter Consumed and Nutrients Digested Daily and per 1000 lbs. Live Weight.

	Average Weight	D. M.	Nutrients		
			Protein	C. H.	Fat
Alice	808	8.98	.297	5.45	.38
Belle	1010	9.23	.277	5.08	.37
Average		9.10	.287	5.27	.375

While the cows maintained their weight during the experiment, with the exception noted, there were indications that they had not been fully nourished; probably due chiefly to the small amount of protein in the ration. They looked dull, their skin was not loose and their coats were dry and harsh and were not shed until late in the spring.

During the winter of 1897-98 three barren dry cows were fed trial rations of food of maintenance on fodder corn, beets and oil meal. The preliminary feeding began in November but the fodder corn did not cure out to a uniform water content until the latter part of December which caused considerable variation in weight, so the data covers only a period from December 30th to April 11th. The following table gives the weight of the cow Alice during the experiment.

ALICE. 1897–8.

TABLE IX.—Giving Dates and Weights.

Date	Weight	Date	Weight	Date	Weight
Dec. 30	750	Feb. 3	750	Mar. 10	755
Jan. 3	760	Feb. 7	740	Mar. 14	758
Jan. 6	762	Feb. 10	735	Mar. 17	755
Jan. 10	765	Feb. 14	742	Mar. 21	750
Jan. 13	765	Feb. 17	748	Mar. 24	748
Jan. 17	762	Feb. 21	750	Mar. 28	755
Jan. 20	765	Feb. 24	750	Mar. 31	752
Jan. 24	750	Feb. 28	762	April 4	752
Jan. 27	765	Mar. 3	752	April 7	760
Jan. 31	760	Mar. 7	755	April 11	762

During the month of February it was noticed that she seemed to have difficulty in masticating food and occasion-

ally a swelling appeared on the right side of the jaw. She was killed at the close of the experiment and it was found that a tooth had been broken which probably was painful and caused shrinkage in weight. The data therefore can be used only to show how important it is in experimental work with live stock to keep close watch over the animals employed, and how a small matter may destroy the value of data obtained.

TABLE X.—Dry Matter and Nutrients Consumed Daily.

	D. M.	Digested			Daily Gain
		Protein	C. H.	Fat	Lbs.
Actually Consumed	8.89	.59	4.85	.08	.27
Per 1000 lbs. Live Weight	11.79	.78	6.43	.10	

RECORD OF BELLE.—1897–8.

TABLE XI.—Giving Dates and Weights.

Date	Weight	Date	Weight	Date	Weight
Dec. 30	1065	Feb. 3	1055	Mar. 10	1070
Jan. 3	1052	Feb. 7	1062	Mar. 14	1075
Jan. 6	1046	Feb. 10	1060	Mar. 17	1072
Jan. 10	1032	Feb. 14	1070	Mar. 21	1075
Jan. 13	1055	Feb. 17	1070	Mar. 24	1075
Jan. 17	1025	Feb. 21	1072	Mar. 28	1075
Jan. 20	1065	Feb. 24	1062	Mar. 31	1078
Jan. 24	1045	Feb. 28	1070	April 4	1080
Jan. 27	1050	Mar. 3	1070	April 7	1075
Jan. 31	1045	Mar. 7	1075	April 11	1082

The different weighings clearly show there was a steady gain. In the first column the weight ranged from 1025 to 1065, while in the second the range is from 1055 to 1075, and in the third from 1070 to 1082. Taking the first column as preliminary and the difference between her average weight reported in the second column, with that in the third as the gain made, there is a difference of 9 pounds or at the rate of .27 of a pound per day.

The dry matter consumed and nutrients actually digested, as determined by a digestion experiment, were as follows:

TABLE XII.—Giving Nutrients Consumed Daily.

	D. M.	Digested			Daily Gain
		Protein	C. H.	Fat	Lbs.
Actually Consumed	11.70	.73	5.51	.11	.27
Per 1000 lbs, live weight	10.93	.68	5.15	.10	

RECORD OF LOTTIE.—1897-8.

TABLE XIII.—Giving Dates and Weights.

Date	Weight	Date	Weight	Date	Weight
Dec. 30	680	Feb. 3	700	Mar. 10	710
Jan. 3	655	Feb. 7	697	Mar. 14	710
Jan. 6	670	Feb. 10	695	Mar. 17	710
Jan. 10	660	Feb. 14	695	Mar. 21	712
Jan. 13	678	Feb. 17	700	Mar. 24	712
Jan. 17	662	Feb. 20	700	Mar. 28	715
Jan. 20	665	Feb. 24	703	Mar. 31	715
Jan. 24	692	Feb. 28	710	April 4	710
Jan. 27	700	Mar. 3	710	April 7	710
Jan. 31	702	Mar. 7	705	April 11	705

From a careful examination of the different weights it is evident that she was gradually gaining. Her weight in the first column ranged from 655 to 702, while in the second it ranged from 695 to 710, and in the third from 705 to 715. It is exceedingly difficult to determine exactly the gain made. But by assuming that the weights during the five weeks covered by the first column are preliminary and deducting the average weight in the second column from that of the third, there is a difference of 9 pounds or a gain of .27 of a pound daily. The cow was naturally very restless and discontented and since she was a stranger in the herd and not accustomed to confinement she probably did not do normal work.

The dry matter consumed daily and nutrients actually digested were as follows:

TABLE XIV.—Giving Nutrients Consumed Daily.

	D. M.	Digested			Daily Gain
		Protein	C. H.	Fat	Lbs.
Actually Consumed	8.53	.51	3.80	.07	.27
Per 1000 live weight	12.08	.72	5.38	.10	

RECORD OF LOTTIE.—1898-99.

TABLE XV.—Giving Dates and Weights.

Date	Weight	Date	Weight	Date	Weight
Nov. 7	705	Jan. 2	750	Feb. 27	757
Nov. 14	710	Jan. 9	750	Mar. 6	762
Nov. 21	730	Jan. 16	750	Mar. 13	760
Nov. 28	725	Jan. 22	757	Mar. 20	760
Dec. 5	732	Jan. 30	752	Mar. 27	765
Dec. 12	742	Feb. 6	755	April 3	762
Dec. 19	750	Feb. 13	752	April 10	765
Dec. 26	745	Feb. 20	758	April 17	765

During this trial we again find that there was a gradual gain though it was less after the second of January. In the first column the weights ranged from 705 to 750 lbs. while in the second they ranged from 750 to 758, and in the third from 757 to 765. The average weights in the third column exceed those of the second column by 9 pounds, making an average daily gain of .16 of a pound.

The dry matter consumed daily and nutrients actually digested were as follows:

TABLE XVI.—Giving Dry Matter Consumed and Nutrients Digested Daily and per 1000 Pounds Live Weight.

	Dry Matter	Digested			Daily Gain
		Protein	Carbohydrates	Ether Extract	Lbs.
Actually Consumed	8.42	.39	5.09	.12	.16
Per 1000 lbs. live weight	11.12	.50	6.72	.15	

At the close of the experiment the cow presented clear evidence of having been amply nourished. Her eyes were bright, her movements quick, skin loose and coat new, soft

and glossy. The cows employed in the experiment during the winter previous showed similar indications of having been well nourished. Aside from gaining in weight, and on this account presenting a more smooth appearance, they shed their coat early and it had that bright, glossy appearance which is recognized among stockmen as a sure index of a healthy physical tone.

Combining the results obtained in the last three trials, we have the average daily dry matter consumed and nutrients digested, and gain made and the average for the three years:

TABLE XVII.—Giving Dry Matter and Nutrients Daily per 1000 Pounds Live Weight, and Gain in Weight.

	Year	Dry Matter	Digested			Daily Gain in Weight
			Protein	Carbohydrates	Ether Extract	
Belle	1897-8	10.93	.68	5 15	.10	.27
Lottie	1897-8	12.08	.72	5.38	.10	.27
"	1898-9	11.08	.50	6.72	.15	.16
Average		11.38	.63	5.75	.12	.23
Wolff Standard		18.00	.70	8.00	.10	

The trials on food of maintenance during the three winters with barren dry cows show that, with an average of 11.38 pounds of dry matter daily containing of digestible matter, as determined by actual digestion experiments, .63 of a pound of protein, 5.75 pounds of carbohydrates and .12 of a pound of ether extract, the cows were amply nourished and made a daily average gain of .23 of a pound in live weight. While the cows received on an average .63 of a pound of protein daily it does not follow that it is the minimum amount required since in the last experiment the cow received only .5 of a pound with very satisfactory results.

The experiments justify the conclusion that with cows at rest in stall in comfortable quarters, a ration of 11.5 of dry matter containing of digestible matter, .06 of a pound of protein, .6 of a pound of carbohydrates and .01 of a pound of

ether extract per hundred weight of cow, will be ample for a maintenance ration. Whether this allowance would be sufficient for cows receiving the treatment accorded them in a well regulated dairy in comfortable quarters, and allowed an outing in the yard for an hour or two during pleasant days in winter, still remains to be determined. Pending such determination it is tentatively suggested that for a cow working in the dairy and having ordinarily good care and comfortable quarters the allowance for maintenance be calculated at 1.25 pounds of dry matter, containing .07 of a pound of protein, .7 of a pound of carbohydrates and .01 of a pound of ether extract per hundred pounds live weight. These factors are suggested because they seem warranted by the data obtained, and because it is deemed desirable for convenience in feeding practice, to express the requirements for food of maintenance in the simplest form possible, so it can be understood and used by the average feeder.

The deductions from the data indicate:

That the factors for food of maintenance in the Wolff feeding standard are in excess of the requirements.

That a daily allowance of 11.38 of dry matter containing of nutrients .63 of a pound of protein, 5.75 of carbohydrates and .12 of a pound of ether extract per 1000 pounds live weight resulted in a daily average gain of about a quarter of a pound.

It is tentatively suggested that the food of maintenance for a barren dry cow when at rest in stall be expressed in nutrients .6 of a pound of protein, 6. pounds of carbohydrates and .1 of a pound of ether extract per 1000 pounds live weight and when at work in a dairy with ordinary good care and comfortable quarters, .7 of a pound of protein, 7. pounds of carbohydrates and .1 of a pound of ether extract be allowed per 1000 pounds live weight or one-tenth as much per cwt.

2. NUTRIENT REQUIREMENTS.

This report is a continuation of the one made in bulletin 71 of June, 1901, on a further study of the nutrients actually required by dairy cows in milk production. In the bulletin referred to, the subject of protein requirements only, was considered, while in this, nutrient requirements are taken up.

In bulletin 71 the subject of feeding standards was briefly reviewed and a table submitted from Henry's Feeds and Feeding, giving the several standards, which is reproduced for convenience.

TABLE XVIII.—American and German Feeding Standards for Dairy Cows, Digestible Nutrients per Day per 1000 Pounds Live Weight.

RATION	Dry Matter	Digestible Nutrients			Nutritive Ratio
		Protein	Carbohydrates	Ether Extract	
	Lbs.	Lbs.	Lbs.	Lbs.	
Wolff original (German) feeding ration....	24.0′	2.5	12.5	.4	1:5.4
Woll proposed American ration.....	24.5	2.15	13.27	.74	1:6.9
Atwater and Phelps proposed standard..	25.0′	2.5	12 to 13	.5 to .8	1:5.6
Wolff-Lehmann modified standard—					
I. When giving 11 lbs. of milk daily.	25.0	1.6	10.0	.3	1:6.7
II. When giving 16½ lbs. of milk daily.	27.0	2.0	11.0	.4	1:6.0
III. When giving 22 lbs. of milk daily.	29.0	2.5	13.0	.5	1:5.7
IV. When giving 27½ lbs. of milk daily.	32.0	3.3	13.0	.8	1:4.5
Standard maintenance ration.....	18.0	.7	8.0	.1	1:11.8

′Organic matter.

In general feeding practice it has become apparent that feeding standards based on the weight of animals without reference to product yielded, were not satisfactory guides and that some modification was desirable.

To meet this Dr. Lehmann suggested the modification given in the table, based upon certain stated yields of milk. It appears quite evident that he used the original Wolff factors for daily maintenance, that is, .7 of a pound of digestible protein, 8 pounds of carbohydrates, and .1 of a pound

of ether extract, per one thousand pounds live weight. Calculating the food of maintenance upon this basis, and making allowance for the yield of milk stated in each sub-division in the Lehmann modification, it is found that he prescribes the nutrients required for the production of one pound of milk, as appears in the following table.

TABLE XIX.—Giving Lehmann Feeding Standard Factors, for the Production of One Pound of Milk.

	Protein	Carbo-hydrates	Ether Extract
	Lbs.	Lbs.	Lbs.
When giving 11 lbs. of milk daily	.081	.18	.018
" 16½ lbs. of milk daily	.078	.18	.018
" 22 lbs. of milk daily	.081	.22	.018
" 27½ lbs. of milk daily	.094	.18	.025

It is not clear why the variations given in the table should occur when the different quantities of milk are yielded. While Dr. Lehmann's modification of the Wolff standard may be an improvement on the original, the following questions naturally suggest themselves:

1. Are the factors approximately correct?
2. Are they applicable to any and all grades or qualities of milk yielded?
3. Will they answer for heifers in milk?

These are questions that can be determined only by actual demonstration, for we have reached a stage in American agricultural research, when theoretical formulæ based merely upon calculations made in the laboratory or office carry but little weight.

1. Are the Lehmann Factors Approximately Correct?

The feeding experiment conducted at this station during the winter of 1894-5, in which the cows were given a fixed ration for a period of 154 days, during which time a full flow of milk and yield of butter fat was secured without gain or loss in body weight, throws some light on all of the points raised. Since it will be necessary to refer to the performance of the whole herd and that of some individual animals, the average daily nutrients consumed and milk and butter fat yielded by each animal and by the herd for both periods are given.

TABLE XX.—Giving the Daily Average of Dry Matter and Nutrients Consumed and Milk and Butter Fat Yielded from Nov. 19, 1894, to Feb. 10, 1895. 84 Days.

NAME	Dry Matter	Digestible			Av. Daily Yield		
		Protein	C. H.	Fat	Milk	Per Cent Fat	Butter Fat
Betty	20.53	1.70	10.98	.45	10.03	6.7	.672
Dora	22.53	1.87	12.08	.49	15.02	6.3	.949
Beckley	20.08	1.63	10.72	.43	13.44	5.6	.761
Tricksey	20.53	1.70	10.98	.45	16.78	4.9	.825
Houston	23.23	1.98	12.44	.51	25.00	5.6	1.406
Sweet B	26.91	2.25	14 50	.58	30.81	4.8	1.490
Olive	20.08	1.63	10.72	.43	27.26	3.8	1.050
Topsy	31.49	2.64	16.92	.69	44.39	3.7	1.656
Lou	26.22	2.14	14.10	.55	38.01	3.7	1.410
Quidee	23.29	1.90	12.42	.50	25.55	3.5	.908
Lydia	28.34	2.39	15.22	.62	32.02	3.4	1.087
Countess	28.37	2.38	15.28	.61	45.27	2.4	1.094
Average	24.30	2.01	12.03	.53	26.96	4.1	1.109

TABLE XXI.—Giving the Daily Average of Dry Matter and Nutrients Consumed and Milk and Butter Fat Yielded from Feb. 11 to April 21, 1895. 70 Days.

Name of Cows	Dry Matter	Digestible			Average Daily Yield		
		Protein	Carbo-hydrates	Fat	Milk	Per Cent Fat	Butter Fat
Beckley	21.19	1.68	11.10	.51	13.17	5.59	.736
Countess	29,22	2.40	15.50	.72	41,80	2.53	1.061
Houston	25.24	2.14	13.35	.64	24.88	5.38	1.340
Lou	27.00	2.21	14.10	.67	31.46	3.67	1.154
Olive	21.15	1.67	11.12	.51	21.20	4.12	.884
Reddy	20.94	1.69	11.01	.51	14.49	5.21	.755
Belle	20.56	1.76	10.89	.50	19.38	4.14	.803
Lydia	27.57	2.26	14.49	.68	27.93	3.57	.999
Quidee	22.73	1.85	11.94	.55	25.81	3.49	.902
Sweet B	27.00	2.21	14.21	.67	26.09	5.28	1.379
Topsy	31.93	2.59	16.79	.78	40.82	3.69	1.492
Tricksey	19.61	1.56	10.33	.47	15.73	5.34	.840
Average	24.51	2.00	12.90	.60	25.23	4.07	1.029

It will be seen that the two periods do not cover exactly the same number of days, one being for 84 while the other is for 70 days, but since the daily average of nutrients consumed and yield of milk and butter fat were so much alike, the average of the two will be so nearly the actual average that such use is considered allowable.

TABLE XXII.—Giving Daily Average for 154 Days.

	Weight	Digestible nutrients.			Milk Yielded
		Protein	Carbo-hydrates	Fat	
Period I, 84 days	954	2.01	12.03	.53	26.96
Period II, 70 days	958	2.00	12.90	.60	25.23
Total	1912	4.01	24.93	1.13	52.19
Daily Average	956	2.00	12.46	.56	26.09
Daily for Maintenauce*		.67	6.69	.095	
Daily available for milk		1.33	5.77	.46	26.09
Nutrients to 1 lb. milk		.051	.221	.018	

* At the rate of protein .07; carbohydrates .7 and ether extract .01 per cwt.

From this it is seen that the daily average of nutrients available to a pound of milk did not differ materially from the Lehmann standard except that the herd returned a pound of milk for each .05 of available protein, being about 60 per cent of the amount prescribed by the standard. The average per cent fat in the milk during the winter was 4.07, which is a trifle above the average quality in this country. The discrepancy in the amount of available carbohydrates consumed, per pound of milk yielded is greater than is indicated by the above comparison; because the standard prescribes 8 pounds per thousand pounds live weight for food of maintenance while only 7 pounds are allowed in this table. If this factor is applied to the Lehmann standard it makes an allowance of .27 of a pound of carbohydrates to a pound of milk.

The herd came out of the winter in excellent condition and gave every evidence of having been amply nourished, and returned a maximum yield of both milk and butter fat. The following winter, 1895–6 the herd was composed of, practically the same animals, received on an average a daily allowance of 2.59 pounds of digestible protein, and its performance compared with the winter's work in review, was as follows:

TABLE XXIII.—Giving Daily Average of Nutrients Consumed and Milk and Butter Fat Produced during the Winters 1894-95 and 1895-6.

Year	Weight	Digestible Nutrients.			Milk	Per Cent Fat	Butter Fat
		Protein	Carbo-hydrates	Fat			
1894-5	956	2 00	12.46	.56	26.09	4.10	1.069
1895-6	980	2.59	12.24	.68	25.71	3.93	1.011

The data thus far submitted give strong evidence that the amount of protein prescribed in the feeding standards is greatly in excess of the amount actually needed. The cows yielded more milk and butter fat during the winter they received 2 pounds of protein daily than they did the winter following with a daily allowance of 2.59 pounds.

Since the herd returned its maximum yield and neither gained nor lost in live weight during the winter of 1894-5, it may be assumed, for the time being, *that the Lehmann modification prescribes more nutrients than are needed.*

2. Are the Lehmann Factors Applicable to any and all Grades or Qualities of Milk Yielded?

Inquiring into the question as to the standard being applicable to any grade or quality of milk, a table is compiled from the records of mature cows in the herd, *whose productive powers had been developed to their feeding capacity by careful feeding and handling for several years*, giving the per cent of butter fat in their milk and nutrients required per pound of milk yielded.

TABLE XXIV.—Giving Available Nutrients Consumed per Pound of Milk Yielded by Mature Cows.

	Per Cent Fat	Protein	Carbo-hydrates	Ether Extract	Total
Countess	2.5	.036	.16	.012	.208
Lou	3.7	.040	.20	.014	.254
Topsy	3.7	.042	.20	.014	.256
Olive	4.0	.044	.22	.016	.280
Sweet Briar	5.0	.052	.24	.018	.310
Houston	5.5	.057	.26	.019	.336

By this table it is clearly shown that the amount of nutrients to a pound of milk increases with the increase in the quality of the milk, but not in the same proportion; for

Countess gave milk containing 2.5 per cent of butter fat and used .208 of available nutrients while Sweet Briar gave milk containing twice as much butter fat but did not require twice as much protein or other nutrients. The same is the case with the other cows. The table also shows that in formulating a ration the quality of milk yielded should be considered, as well as the quantity.

Incidentally the table, which is the daily average of 154 consecutive days' work, clearly indicates that other things being equal, the richer the milk the more economical is the production of butter fat. It has been shown that the richer the milk in butter fat the more nutriment is required. Indeed it could not be otherwise, for the per cent of solids in the milk increases with the increase in butter fat, and the rate of increase in energy in rich milk is even greater than the increase in solids, because the richer the milk in butter fat, the greater the per cent of fat to solids not fat.

To show the *rate* of increase in nutrients required for the production of a pound of milk of different quality, the records of Houston and Countess are employed:

TABLE XXV.—Showing Difference in Nutrient Requirements for Milk Testing High and Low in Butter Fat.

	Per Cent Fat in Milk	Protein	Carbo-hydrates	Ether Extract
Houston	5.5	.057	.26	.019
Countess	2 5	.036	.16	.012
Difference for 30 tenths	3.0	.021	.10	.007
Difference for 1 tenth		.0007	.0033	.00023

By this it is seen that in the production of the rich milk the additional nutrient requirements were at the rate of .0007 of protein, .0033 of carbohydrates and .00023 of ether extract for each .1 per cent increase in per cent of butter fat.

Taking the nutrients required for a pound of milk testing 2.5 per cent butter fat as a basis, and the nutrients required in addition for each one tenth per cent increase, we have the following table giving approximately the nutrients required for the production of a pound of milk of a given per cent butter fat.

TABLE XXVI.—Giving Net Nutrients Used by Mature Cows for the Production of One Pound of Milk Testing a Given Per Cent Butter Fat.

	Protein	Carbohydrates	Ether Extract
Milk testing 2.5	.0362	.164	.0124
" 2.6	.0369	.167	.0126
" 2.7	.0376	.171	.0128
" 2.8	.0383	.174	.0131
" 2.9	.0390	.177	.0133
" 3.0	.0397	.181	.0136
" 3.1	.0404	.184	.0138
" 3.2	.0411	.187	.0140
" 3.3	.0418	.190	.0142
" 3.4	.0425	.194	.0145
" 3.5	.0432	.197	.0147
" 3.6	.0439	.200	.0149
" 3.7	.0446	.204	.0152
" 3.8	.0453	.207	.0154
" 3.9	.0460	.210	.0156
" 4.0	.0467	.214	.0159
" 4.1	.0474	.217	.0161
" 4.2	.0481	.220	.0163
" 4.3	.0488	.223	.0165
" 4.4	.0495	.227	.0168
" 4.5	.0502	.230	.0170
" 4.6	.0509	.233	.0172
" 4.7	.0516	.237	.0175
" 4.8	.0523	.240	.0177
" 4.9	.0530	.243	.0179
" 5.0	.0537	.247	.0182
" 5.1	.0544	.250	.0185
" 5.2	.0551	.253	.0187
" 5.3	.0558	.256	.0189
" 5.4	.0565	.260	.0192
" 5.5	.0572	.263	.0194
" 5.6	.0579	.266	.0196
" 5.7	.0586	.270	.0199
" 5.8	.0593	.273	.0201
" 5.9	.0600	.276	.0203
" 6.0	.0607	.280	.0206
" 6.1	.0614	.283	.0208
" 6.2	.0621	.286	.0210
" 6.3	.0628	.289	.0212
" 6.4	.0635	.293	.0215
" 6.5	.0642	.296	.0217
" 6.6	.0649	.300	.0219
" 6.7	.0656	.303	.0222
" 6.8	.0663	.306	.0224
" 6.9	.0670	.309	.0226
" 7.0	.0677	.313	.0229
Co-efficients for Food of Maintenance per cwt.	.07	.7	.01

The table is very closely in accord with the nutrients used to a pound of milk yielded by the mature members of the herd not making material gain in body weight, except that it provides more than was actually used by the cows giving milk of medium quality, say for that testing from 3.5 to 4.5 per cent of butter fat. In the table given, .0007 of a pound of protein available for product was allowed for each .1 of one per cent increase in the per cent fat in the milk, while in fact, the difference was not so great between the lower grades of milk.

To illustrate the *rate* of increase of protein used, per pound of milk yielded by the cows, as their milk was richer

in butter fat, after making allowance for protein needed for maintenance, the following deductions from the record are submitted, though it does not follow that the *rate* of increase of protein per pound of milk, as it increased in fat content, was actually needed.

TABLE XXVII —Showing Rate of Increase in Protein Requirements.

	Per Cent Fat in Milk	Protein to 1 lb. Milk
Lou and Topsy, average	3.7	.041
Countess	2.5	.036
Difference for	12 points	.005
Difference for each point		.0004
Olive	4.0	.044
Countess	2.5	.036
Difference for	15 points	.008
Difference for each point		.0005
Sweet Briar	5.0	.052
Countess	2.5	.036
Difference for	15 points	.016
Difference for each point		.0006
Houston	5.5	.057
Countess	2.5	.036
Difference for	30 points	.021
Difference for each point		.0007

As has been stated, the rate of increase of protein for the various grades of milk was based upon the difference per point between that used by the cow yielding milk containing 2.5 per cent fat and that used by the cow yielding milk testing 5.5 per cent, and more protein is prescribed for cows giving milk of medium quality than they actually used. The slight excess, however, is not a serious objection.

The tables submitted show *that the quality of milk is quite as important a factor in formulating a feeding standard or guide to feeding practice, as quantity of milk yielded.*

3. Are the Lehmann Factors Applicable to Heifers in Milk?

Heifers with first and second calf, covering the periods of their three and four-year old form, make considerable growth which requires nutriment as well as does the elaboration of milk. If the feeding standard is based solely upon the flow of milk and weight of cow, there will be a shortage of nutriment needed. It is obvious that heifers yielding milk similar in quantity and quality may differ in amount of nutrmient actually needed, because they may differ in rate of growth, and on this account there will be a greater variation in nutriment required by different individuals than was found to be the case with mature cows. Since the ratio of nutrients required for growth of body is practically the same as that required for milk production, the extra amount of nutriment needed for growth should be provided for, with the nutrients needed for milk production and not with those calculated for simply food of maintenance. The factors used for food of maintenance for mature cows will, therefore, be applied to heifers. The following table gives a list of heifers in milk during the time covered by the record under review, which was 154 days, except in the case of Reddy, that came in four weeks later, and the nutrients required to a pound of milk after deducting the food of maintenance.

TABLE XXVIII.—Giving Available Nutrients Consumed per Pound of Milk Yielded by Heifers.

	Per Cent Fat	Protein	Carbo-hydrates	Ether Extract
Lydia	3.5	.052	.25	.018
Quidee	3.5	.049	.24	.016
Tricksey	5.1	.068	.33	.023
Beckley	5.6	.079	.37	.027
Reddy	5.2	.079	.38	.029
Average for Heifers		.065	.314	.022
Average for Mature Cows		.045	.213	.015

The heifers used nutrients in proportion to the quantity and quality of milk yielded, the same as was the case with the mature cows, but they returned a pound of milk to .065 of protein available for product, while the mature cows returned a pound of milk to .045 of protein; the heifers requiring nearly one-half more available nutrients to a pound of milk than did the cows.

Again seeking the rate of increase in nutrients required for each .1 per cent increase in butter fat, between the average amount of nutrients required by the heifers yielding milk containing 3.5 per cent of butter fat, and those yielding milk testing above 5 per cent, it is found to be .00125 of a pound of protein, .00567 of carbohydrates and .000432 of ether extract. Multiplying this by ten and subtracting the product from the nutrients used by the heifers yielding milk

TABLE XXIX.—Giving Net Nutrients Required by Heifers for the Production of One Pound of Milk Testing a Given Per Cent of Butter Fat.

	Protein	Carbo-hydrates	Ether Extract
Milk Testing 2.5	.0380	.188	.0127
" 2.6	.0393	.194	.0131
" 2.7	.0405	.200	.0135
" 2.8	.0418	.205	.0140
" 2.9	.0430	.211	.0144
" 3.0	.0443	.217	.0148
" 3.1	.0455	.222	.0153
" 3.2	.0468	.228	.0157
" 3.3	.0480	.234	.0161
" 3.4	.0493	.239	.0166
" 3.5	.0505	.245	.0170
" 3.6	.0518	.251	.0174
" 3.7	.0530	.256	.0179
" 3.8	.0543	.262	.0183
" 3.9	.0555	.268	.0187
" 4.0	.0568	.273	.0192
" 4.1	.0580	.279	.0196
" 4.2	.0593	.285	.0200
" 4.3	.0605	.290	.0205
" 4.4	.0618	.296	.0209
" 4.5	.0630	.302	.0213
" 4.6	.0643	.307	.0218
" 4.7	.0655	.313	.0222
" 4.8	.0668	.319	.0226
" 4.9	.0680	.324	.0230
" 5.0	.0693	.330	.0235
" 5.1	.0705	.336	.0239
" 5.2	.0718	.341	.0243
" 5.3	.0730	.347	.0248
" 5.4	.0743	.353	.0252
" 5.5	.0755	.358	.0256
" 5.6	.0768	.364	.0261
" 5.7	.0780	.370	.0265
" 5.8	.0793	.375	.0269
" 5.9	.0805	.381	.0274
" 6.0	.0818	.387	.0278
Coefficients for Food of Maintenance per cwt.	.07	.7	.01

testing 3.5 per cent butter fat, gives approximately, that required in the production of milk testing 2.5 per cent butter fat, which is .038 of a pound of protein, .1883 of carbohydrates and .01268 ether extract per pound of milk yielded, from which is deduced the following graduated scale of approximate nutrient requirements for the production of a pound of milk testing a given per cent of butter fat, based upon the performance of the heifers in the station herd covering a period of 154 days.

The factors of nutrients required for the production of one pound of milk by the heifer Reddy are not used in calculating the rate of increase of nutrients because she made gain more than for normal growth, as will be seen from the following table, giving the weight at the beginning and close of the experiment.

TABLE XXX.—Giving Gain in Weight by Each Heifer.

	Lydia	Quidee	Tricksey	Beckley	Reddy
At Close	1083	869	763	862	791
At Beginning	1014	785	723	839	747
Total Gain	69	84	40	23	44
Daily Gain	.47	.57	.27	.16	.78

The rate of gain made by Reddy shows why the nutrients consumed daily were not proportionate with the yield and quality of milk. Tricksey gave milk testing 5.1 per cent fat and returned a pound of milk to .068 of a pound of protein, while Reddy gave milk testing only .1 of a per cent higher returned a pound of milk to .079 of protein, showing that she converted part of the nutrients into body fat. Neither was she in milk during the earlier weeks of the experiment. The weights are the average of three weekly weighings at both the beginning and close, and for Lydia, Quidee, Tricksey and Beckley they cover a period of 147 days, and for Reddy only 56 days.

The data submitted show *that heifers require more nutrients per pound of milk yielded than do mature cows.*

OBSERVATIONS.

It has long since been recognized that because of the difference in composition of the various kinds of feed stuffs no single standard of composition for all feeds would be practical, and yet, while there is as great a difference in the composition of milks as there is in feed stuffs, there has been no adjustment of the nutrients in the ration to the quantity and character of the solids contained in the milk yielded, though, as has been shown, such an adjustment appears to be quite simple and practicable. If in formulating a ration it is deemed necessary in economic milk production, to take note of the fact that one feed stuff contains 12 per cent of protein and another 20 per cent, is it not equally important in our attempt to adjust the ration to the needs of the cow in milk production to also take into account the fact that one cow may give milk containing 3 per cent fat while that of another may contain twice as much? It would seem quite as consistent to feed an animal food regardless of its composition as to feed an assumed balanced ration regardless of the composition of the product which is to be elaborated from the nutrients in the food.

Great stress has been placed upon the fact that the nutrients in milk have a nutritive ratio of approximately one to five, and that therefore the ration for a milch cow should have a similar nutritive ratio; apparently overlooking the fact that only about fifty per cent of the ration is used in milk production and the balance for maintenance of body. If note is taken of the fact that about half the ration is used for maintenance and that the maintenance ration has a nutritive ratio of one to ten, it becomes apparent that for the production of milk of average quality by an animal of average milk producing powers the nutritive ratio of the ration should be approximately 1 : 7.5. But since animals vary in productive powers, and since this variation is not in proportion to weight of body, it follows that if rations are adjusted to the actual requirements of animals the nutritive ratio of the rations will also vary, as will be shown.

The author has used tables XXVI and XXIX for two years in class work with highly satisfactory results. The tables of nutrients required to a pound of milk ranging in

per cent fat from 2.5 to 6.5, are printed on pasteboard cards 7x3½ inches, and on the reverse side a table giving the nutrients in a pound of ordinary feeding stuffs. Given the daily yield of milk in pounds, its per cent of butter fat, and the weight of the cow expressed decimally, it is an easy matter to determine the required ration. As an illustration, suppose a mature cow weighs 825 pounds, gives 20 pounds of milk daily, testing 4 per cent butter fat. One pound of 4 per cent milk requires of protein .0467, carbohydrates .214, and of ether extract, .0159, multiplying these factors by 20 it is found that for the production of milk she needs .934 of protein, 4.28 of carbohydrates and .318 of ether extract. For food of maintenance multiply .07 protein, .7 carbohydrates and .01 of ether extract (maintenance formula) by 8.25 which gives protein .578, carbohydrates 5.78 and ether extract .082; adding to this the nutrients required for milk production, we have 1.51 of protein, 10.06 carbohydrates and .40 ether extract, the nutrients required in the ration. They should be supplied in such manner with reference to bulk that it will satisfy the appetite. A ration like this should be largely made up of roughage.

But suppose a cow weighing 850 pounds yields 40 pounds of 4 per cent milk daily, the required ration would be:

	Pro.	C.H.	Fat		Pro.	C.H.	Fat
	(.0467	–.214	–.0159)	x 40 =	1.868	– 8.56	–.636
	(.07	–.7	–.01)	x8.50 =	.595	– 5.95	–.085
Ration required,					2.463	–14.51	–.721

A ration like this should be largely composed of grain so that it will not contain so much bulk that she will go off her feed, and yet furnish the nutrients required. If a cow's ration is adjusted in bulk with reference to her feeding capacity and in nutriment content to the work she is doing, she will not be overfed nor go off her feed. A cow will not do her best unless she is so fed that she is satisfied, but the ration should not contain more nutriment than she actually needs. From this it follows that cows do not require a uniform nutritive ratio in their rations, but that it varies according to the quantity of milk yielded and weight of cow.

To illustrate, let us take a cow weighing 1200 pounds and yielding 20 pounds of milk daily, and one weighing 850 pounds yielding 40 pounds of milk, both testing 4 per cent fat.

	Pro.	C. H.	Fat
Nutrients for 1 lb. of 4 per cent milk,	.0467	.214	.0159
Nutrients for 1 cwt., maintenance,	.07	.7	.01

For cow weighing 1200 lbs. and yielding 20 lbs. of 4 per cent milk:

	Pro.	C. H.	Fat	
Nutrients for 20 lbs. milk,	.93	4.28	.32	
Nutrients for 12 cwt. maintenance,	.84	8.40	.12	
Ration required,	1.77	12.68	.44	
Nutritive ratio,				1:7.7

For cow weighing 850 lbs. and yielding 40 lbs. of 4 per cent milk.

	Pro.	C. H.	Fat	
Nutrients for 40 lbs. of milk,	1.87	8.56	.64	
Nutrients for 8.5 cwt. maintenance,	.59	5.95	.08	
Ration required,	2.46	14.51	.72	
Nutritive ratio,				1:6.5

But if the cow weighing 12 cwt. yields 40 pounds of milk per day and the cow weighing 8.5 cwt. yields 20 pounds, the nutrient requirements for their respective rations according to table—will be as follows:

	Pro.	C. H.	Fat	
Nutrients for 40 lbs. of 4 per cent milk,	1.87	8.56	.64	
Nutrients for 12 cwt. maintenance,	.84	8.40	.12	
Required ration,	2.71	16.96	.76	
Nutritive ratio,				1:6.8
	Pro.	C. H.	Fat	
Nutrients for 20 lbs. of 4 per cent milk,	.93	4.28	.32	
Nutrients for 8.5 cwt. maintenance,	.59	5.95	.08	
Required ration,	1.52	10.23	.40	
Nutritive ratio,				1:7.3

In prescribing rations upon the basis of flow and quality of milk and weight of cow and using the factors given in the table the nutritive ratio becomes a factor of very little importance the same as is the case with dry matter in a ration.

If the nutrients required or a given flow of milk are provided for in the concentrates the food of maintenance may be secured by feeding at least a portion of the roughage *ad lib.* If the grain mixture has a nutrive ratio of 1 to 5 or 5.5 it will fairly meet the requirements.

In adjusting rations for cows fresh in milk note should be taken of surplus nutriment stored in the body during the time that a cow goes dry. If she gained rapidly in weight and is well rounded out with fat she will be able to do normal work during the first few weeks of her lactation on a light grain ration, for she will use the stored fat in generating body heat and energy and may also use some in the elaboration of milk solids. So as this milking-down in body weight takes place the concentrates should be gradually increased so that she will be on full feed by the time she reaches her normal working weight. From then on the amount of concentrates should be as constant as the flow of milk will permit until after the sixth month of gestation when it should be gradually decreased so she will go dry during the seventh, when a couple of pounds a day will suffice.

The deduction from the data indicates that the Wolff feeeding standard for dairy cows is fairly correct in the average amount of total nutriment required. but faulty in that it prescribes an excess of protein and in the assumption that cows need nutrients in proportion to their weight.

That the Wolff-Lehmann standard is faulty in that it prescribes an excess of protein and other nutrients; does not designate the nutrients required upon a basis of a unit in weight of milk; does not recognize the fact that quality of milk yielded should be considered as well as quantity, nor, that heifers require more nutrients for a given flow of milk than mature cows.

That the nutrient requirements in milk production depend:

1st.—Upon the weight of the cow.

2nd.—Upon the quantity of milk yielded.

3rd.—Upon the quality of the milk, and

4th.—Upon the age of the cow.

3. PROTEIN REQUIREMENTS.

The experimental feeding of the dairy herd for the winter 1901-2 was planned to secure more data for the further study of protein requirements in milk production. The subject is one of great pecuniary importance to the feeder because food stuffs containing a high per cent of protein are expensive and if cows require less protein than the standards have prescribed, the fact should be definitely determined so that farmers will not be led into incurring unnecessary expense in providing feed for their cows.

The basement in which the dairy stock is kept is partitioned into four divisions, each of which will accommodate 20 cows, and has two alleys, one running lengthwise through the middle and another crosswise, dividing the cows into four groups of five each. In the 1st division groups 1 and 2 were fed ration I; groups 3 and 4, ration II; in the 2nd division groups 5 and 6 received ration III, and groups 7 and 8, ration IV. The cows were not arranged with reference to this experiment, but were left for the winter just as they happened to stand when the experiment began. Since some were farrow, some far advanced in their period of lactation, some to come in during the experiment and others fresh in milk, the records of all are not included in the principal tables from which deductions are made. For tables cows were selected that were doing normal work. In the first division no disturbance of a serious character took place during the winter. But one cold night the door leading from the second division to the third, which is a covered runway, was left open accidentally, and the cows were subjected to a draft, which gave some of them severe colds, proving fatal in one case—Rose—and causing serious inflammation in the udder with another—Tricksey. But fortunately, with Rose, the cold did not take a serious turn until toward spring, when it was necessary to close her record a week before the end of the experiment. Tricksey's condition was more crit-

ical at the time when the accident occurred, but being young, full of vigor and in good condition, she was soon again in good working order.

It was intended to maintain a fixed ratio between grain and roughage for all the cows but in some cases a slight deviation had to be made to feed each to her full limit. The directions were, to feed by weight five times as much corn silage as grain and half as much hay as grain, but in certain cases it was found necessary to deviate a little from this rule. On this account there is a slight variation in the average nutritive ratio of the rations fed to cows in the same group. The rations were made up as follows:

For Group I,—The grain was equal parts corn, bran and gluten meal.

For Group II,—The grain was corn and bran, 4 parts each, and gluten meal 1 part.

For Group III,—The grain was equal parts corn, barley and oats, except Letta, that received bran instead of oats.

It was not known what the nutritive rotios of the several rations would be because the composition of the feed stuffs was not known at the time the experiment began, but it was estimated that a ration containing 8 pounds of grain with the roughage accompanying it would contain of dry matter and nutrients as follows:

TABLE XXXI.—Rations as Estimated.

RATION	Dry Matter	Digestible Nutrients			Nutritive Ratio
		Protein	C. H.	Ether Extract	
I	19.32	2.00	10.55	.53	1:5.8
II	19.29	1.62	10.66	.53	1:7.3
III	19.24	1.37	10.95	.50	1:8.8

The estimated nutrient content of the rations was not made from the American table of average composition of feed stuffs but upon Minnesota averages taking into account the character of the soil upon which the roughage was grown and the condition of the weather during the growing season. By chemical analysis the rations showed the following composition:

TABLE XXXII.—Actual Composition of the Rations Fed.

RATION	Digestible Nutrients			Nutritive Ratio
	Protein	C. H.	Ether Extract	
I	2.04	11.79	.53	1:6.3
II	1.68	11.75	.57	1:7.6
III	1.32	11.76	.50	1:9.7

It will be observed that the rations contained more carbohydrates than was estimated and were therefore a little wider than was intended, though their protein content fairly met expectations.

The corn silage was grown in double drills requiring about a bushel of seed to the acre, but the stand was not as good as was desired on account of some of the seed failing to germinate. In the rows the stalks were about 4 inches apart on the average and contained some small nubbins. It was planted about the middle of June and cut the last week in August.

The hay was from bottom land prairie and was of poor quality, badly bleached and had little flavor, but on account of the small quantity fed, was all consumed.

The beet pulp was not of good quality as some had been too much exposed to the air which caused some fermentation to take place. The cows did not seem to take to it kindly and would probably have done better work without it.

The composition of the food stuffs is given in the following table:

TABLE XXXIII.—Giving Percentage Composition of Food Stuffs as Determined by the Chemical Division.

	Dry Matter	Crude Protein	Ether Ex.	Crude Fiber	Carbohydrates	Digestible		
						Protein	C. H.	Ether Ex.
Corn	88.60	11.00	4.69	2.41	69.13	6.60	65.40	4.03
Barley	87.73	14.19	3.36	7.25	60.34	9.93	59.13	2.99
Oats	88.80	13.69	4.47	12.99	54.10	10.68	43.72	3.71
Bran	88.78	17.60	5.12	11.36	47.46	14.08	35.95	3.89
Gluten M	90.47	36.06	3.74	3.16	45.88	32.09	44.44	3.47
Corn Silage	24.62	2.38	.66	7.29	12.72	1.24	13.30	.56
Prairie Hay	89.10	5.78	2.02	32.56	41.89	2.72	43.74	.97
Beet Pulp	9.97	1.02	.08	2.29	6.23	.64	7.13	.04

Feeding commenced with the morning of November 11, and continued without any change in feed until the morning of February 17th, from and after which a new supply of grain was fed and corn fodder was substituted for silage, and a new supply of prairie hay of poor quality was used. The tables of food consumed and milk and butter fat yielded are the daily averages for the eight consecutive weeks—beginning with December 30th and ending with February 16th, except that the records of two cows in groups I and III extend from 1 to 3 weeks into the fodder-corn period.

TABLE XXXIV.—List of Cows.

NAME	Age	BREEDING	Date of Calving	Remarks
Dorrit	9	Grade Jersey,	September 6, 1901,	
Euroma	4	Jersey,	October 16, 1901,	
Iris	3	Brown Swiss,	December 14, 1901,	
L'Etoile	12	Jersey,	January 19, 1902,	
Topsy	6	Jersey-Holstein,	January 4, 1902,	
Trust	6	Jersey,	November 12, 1901,	
Countess	6	Holstein,	October 17, 1901,	
Dora F	9	"	December 12, 1901,	
Fay	3	"	November, 1901,	
Fly T	13	Ayrshire,	November 18, 1901,	
Houston	6	Jersey-Guernsey,	November 17, 1901,	
Pride	6	Jersey,	November 29, 1901,	
Delle II	6	Grade Jersey,	December 3, 1901,	
Klondike	8	Jersey-Holstein,	April 5, 1901,	Aborted, farrow,
Puss	9	Jersey,	January 15, 1902,	
Rose	10	Grade Short-Hn.	January 12, 1902,	
Tricksy	5	Guernsey,	December 12, 1901,	
Letta	3	Jersey,	November 6, 1901,	
Euroma II	2	"	November 2, 1901,	
Duchess	5	"	October 11, 1900,	Farrow,
Leeoma	4	"	August 3, 1901,	Farrow,
Lou	5	Holstein,	February 23, 1901,	
Nora	7	Grade Jersey,	July 28, 1901,	
Shorty	10	Native,	July 25, 1901,	
Sweet Briar	17	Guernsey,	December 9, 1901,	
Trusty Lee	2	Jersey,	December 19, 1901,	

The records of all the cows are not used in the tables because in order to make them comparable they must be under fairly similar conditions, especially as to time of lactation; for the food or nutriment required for a given product varies considerably in the early stages of lactation. But after 8 or 9 weeks they become remarkably constant for an indefinite time unless interrupted by a new period of gestation.

The following tables give the daily average consumption of food by the several groups and its dry matter content.

TABLE XXXV.—Group I, Giving Pounds Food Consumed Daily.

The grain being equal parts of Corn, Bran and Gluten Meal.

COWS	Grain	Silage	Fodder Corn	Prairie Hay	Beet Pulp	Dry Matter
Dorrit	8	40		4	14.5	21.98
Euroma	7	35		3.5	13.5	19.32
L'Etoile	7.8	11	10	4	9.7	20.56
Iris	7.7	37		4	13.9	20.74
Topsy	8.6	25.75	6.7	4.5	15	23.76
Trust	8	33		4	14.5	20.25

TABLE XXXVI.--Group II, Giving Pounds of Food Consumed Daily.

The Grain being Corn 4, Bran 4, Gluten Meal 1.

Cows	Grain	Silage	Prairie Hay	Beet Pulp	Dry Matter
Countess	9	44.4	4.5	17.2	24.64
Dora F	9.9	48.7	5	13	26.53
Fay	7.1	35.6	3.6	6.5	18.93
Fly T	7	39 4	3.9	7.7	20.20
Houston	8	32	4	5.2	19.07
Pride	7	35	3.5	13	19.25

TABLE XXXVII.—Group III, Giving Pounds of Food Consumed Daily.

The Grain being equal parts Corn, Barley and Oats.

Cows	Grain	Silage	Fodder Corn	Prairie Hay	Beet Pulp	Dry Matter
Delle II	7	35		3.5	8 75	18.79
Klondike	8	40		4	14	21.83
Letta	7	29.7		3.5	13	17.19
Puss	7.9	12.4	10	3.9	9.75	20.82
Rose	7.2	21.2	6	4	13	20.29
Tricksey	7.7	40		3.9	7.25	20.89

The quantity of fodder corn and beet pulp entered in the above tables is not the amount taken while these were fed, but the average for the whole period, so by multiplying them them by 56, the time covered, gives the total amount consumed.

The following tables give the daily average of nutrients consumed and the pounds of milk, butter fat and milk solids

yielded during the period. Since a nutrient is something that nourishes, the term digestible seems superfluous and is therefore not used, as nutrient refers only to that part of a food stuff which is digestible.

TABLE XXXVIII.—Giving Digestible Nutreints Consumed and Products Yielded Daily by Group I.

Cows	Crude Protein	Carbo-hydrates	Ether Extract	Milk	Per Cent Fat	Butter Fat	Total Solids
Dorrit	2.104	11.99	.57	21.98	5.40	1.186	3.207
Euroma	1.847	10.55	.50	21.30	5.47	1.165	3.118
L'Etoile	2.014	12.17	.49	27.67	4.73	1.309	3.779
Iris	1.975	11.31	.53	25.88	3.54	.916	3.176
Topsy	2.275	13.64	.57	37.77	3.98	1.503	4.897
Trust	2.018	11.08	.53	32.00	4.64	1.484	4.246
Average	2.039	11.79	.53	27.77	4.54	1.260	3.737

TABLE XXXIX.—Giving Digestible Nutrients Consumed and Products Yielded Daily by Group II.

Cows	Crude Protein	Carbo-hydrates	Ether Extract	Milk	Per Cent Fat	Butter Fat	Total Solids
Countess	1.930	10.61	.65	36.39	3.18	1.157	4.060
Dora F	2.084	14.54	.70	37.30	3.27	1.220	4.229
Fay	1.489	10.33	.51	26.23	3.52	.923	3.042
Fly T.	1.538	11.02	.53	30.13	3.93	1.184	3.723
Houston	1.559	10.40	.52	23.25	4.98	1.159	3.261
Pride	1.505	10.62	.51	30.31	4.42	1.339	3.999
Average	1.684	11.75	.57	30.60	3.80	1.164	3.719

TABLE XL.—Giving Digestible Nutrients Consumed and Products Yielded Daily by Group III.

Cows	Crude Protein	Carbo-hydrates	Ether Extract	Milk	Per Cent Fat	Butter Fat	Total Solids
Delle II	1.221	10.74	.48	27.85	4.00	1.115	3.542
Klondike	1.427	12.56	.56	22.75	4.92	1.120	3.073
Letta	1.261	10.15	.46	19.22	5.65	1.087	2.874
Puss	1.365	12.94	.48	31.89	4.69	1.496	4.237
Rose	1.310	12.25	.48	30.81	3.50	1.078	3.728
Tricksey	1.351	11.91	.54	28.50	4.20	1.198	3.689
Average	1.322	11.76	.50	26.84	4.40	1.182	3.524

TABLE XLI.—Giving a Summary in Pounds of Digestible Nutrients Consumed and Products Yielded by the Three Groups.

Group	Crude Protein	Carbo-hydrates	Ether Extract	Milk	Per Cent Fat	Butter Fat	Total Solids
I.	2.039	11.79	.53	27.77	4.54	1.260	3.737
II.	1.684	11.75	.57	30.60	3.80	1.164	3.719
III.	1.322	11.76	.50	26.84	4.40	1.182	3.524

The amount of nutrients consumed daily other than crude protein by the different groups was remarkably similar, groups I and II each receiving 12.32 pounds while group III received 12.26 pounds, being only .06 of a pound less per day. Of protein, group I received 2.039 pounds daily and yielded 27.77 pounds of milk testing 4.54 per cent fat. Group II received 1.684 of protein and gave 30.60 pounds of milk testing 3.8 per cent butter fat and group III taking ration 4, received 1.322 pounds of protein daily and returned 26.84 pounds of milk testing 4.4 per cent butter fat. The sufficiency of the rations containing different amounts of protein cannot be measured by the quantity of milk yielded because the milks from the three groups differed in quality. The yield of butter fat is a better guide as to the productive virtue of the rations. Group I, that received 2,039 of protein daily, yielded 1.260 lbs. butter fat, while group II, with 1.684 of protein, gave 1.164 of butter fat and group III with 1.322 of protein gave 1.182 of butter fat, showing that the difference in the yield was not caused by the difference in protein supply alone, because croup III returned more butter fat than group II. Comparing the yield of milk and butter fat by the different groups with the nutrients consumed by each, it appears that a ration containing 1.322 of protein is practically as potent in milk production as are the rations that contain 1.684 and 2.039 pounds of protein respectively; that the product yielded bears a closer relation in quantity to *total* nutrients consumed than to the protein supply or nutritive ratio of the rations.

In seeking for further light as to the sufficiency of the protein in the different rations, by examining into the products returned to available nutrients consumed, the following tables, taking into account the food of maintenance, are submitted:

TABLE XLII.—Giving the Weight of Cows in Group I. Total Nutrients, Nutrients for Maintenance, Nutrients Available for Products, and Nutrients to Products Yielded.

Group I	Weight	Nutrients Daily	For Maintenance	Net Nutrients	Net Nutrients to 100 lbs Milk	1 lb. Butter Fat	1 lb. Total Solids
Dorrit	902	14.66	7 03	7.63	34.72	6.44	2.38
Euroma	780	12.90	6.08	6.82	32.02	5.85	2.19
L'Etoile	920	14.67	7.18	7.49	27.07	5.72	1.98
Iris	1034	13.82	8.06	5.76	22.27	6.29	1.81
Topsy	921	16.49	7.18	9.31	24 64	6.19	1.90
Trust	785	13.63	6.12	7.51	23.45	5.06	1.77
Average	890	14.36	6.94	7.42	26.72	5.89	1.98

TABLE XLIII.—Giving the Same for Group II.

Group II	Weight	Nutrients Daily	For Maintenance	For Product	Net Nutrients to 100 lbs Milk	1 lb. Butter Fat	1 lb. Total Solids
Countess	1040	16.18	8.11	8.07	22.18	6.98	1.99
Dora F	1197	17.33	9.34	7,99	21.41	6.54	1.89
Fay	780	12.33	6.08	6 25	23.81	6.77	2.05
Fly T	860	13.08	6.71	6.37	21.65	5.38	1.71
Houston	811	12.47	6.32	6.15	26.47	5.31	1.89
Pride	769	12.63	6.00	6.63	21 87	4.95	1.66
Average	909	14.00	7.09	6.91	22.59	5.94	1.86

TABLE XLIV.—Giving the Same for Group III.

Group III	Weight	Nutrients Daily	For Maintenance	For Product	Net Nutrients to 100 lbs Milk	1 lb. Butter Fat	1 lb. Total Solids
Delle II	718	12.45	5.60	6.85	24.58	6.14	1.93
Klondike	943	14.54	7.35	7.19	31.61	6.42	2.34
Letta	716	11.87	5 58	6.29	32.72	5.78	2.19
Puss	834	14.79	6.50	8.29	25.98	5.54	1.95
Rose	993	14.03	7.74	6.29	20.43	5.84	1.69
Tricksey	874	13.80	6.82	6.98	24.49	5.83	1.89
Average	846	13.58	6.60	6.98	26 00	5.90	1.98

TABLE XLV.—Giving the Averages of the Groups in Weight, Total Nutrients Daily, Nutrients for Maintenance, Nutrients Available for Product, and Nutrients to Products Yielded.

Group	Wt.	Total Nutrients Daily	For Maintenance	For Product	Net Nutrients to		
					100 lbs. Milk	1 lb Butter Fat	1 lb Total Solids
I	890	14.36	6.94	7.42	26.72	5.89	1.98
II	909	14.00	7.09	6.91	22.59	5.94	1.86
III	846	13.57	6.60	6.97	26.00	5.90	1.98

By eliminating the nutrients calculated for food of maintenance at the rate of Pro. .07, C. H. .7, and ether extract .01 per cwt., it is found that the cows in Group I, that received 2.039 pounds of protein daily, returned a hundred pounds of milk testing 4.54 per cent butter fat to 26.72 pounds of net nutrients; that the cows in Group II, that received 1.684 pounds of protein daily, returned a hundred pounds of milk, testing 3.8 per cent butter fat to 22.59 pounds of net nutrients, and that the cows in Group III, that received 1.322 pounds of protein daily, returned a hundred pounds of milk testing 4.4 per cent butter fat to 26.00 pounds of net nutrients. That is, ration III having 1.32 of protein and with a nutritive ratio of 1 : 9.7 appeared as potent for milk production as was ration I having 2 pounds of protein and a nutritive ratio of 1 : 6.3, and that the nutrients required in milk production were proportionate with the quality of the milk yielded.

Also, comparing the nutrients available for product with the butter fat yielded, it appears that the nutrients required to a pound of fat were very nearly the same with each group, regardless of the protein supply, since the milk testing 4 54 per cent required 5.89 pounds of nutrients to a pound of fat, that testing 4.4 per cent required 5.90 pounds of nutrients to a pound of fat, and that testing 3.8 required 5.94 pounds of nutrients.

Again, comparing the available nutrients in the rations with the total milk solids returned, it appears that the group of cows yielding milk testing 3.8 per cent fat returned one pound of milk solids to 1.86 pounds of nutrients, that the group of cows yielding milk testing 4.40 and 4.54 per cent fat respectively returned a pound of milk solids to 1.98

pounds of nutrients; that is, the milk solids produced did not depend so much on the protein content of the rations, as upon the total nutrients, and the character of the milk solids with reference to the per cent fat to solids not fat.

Since the group of cows that received the rations differing in protein content, differed in live weight, it may be of interest to note the amount of protein they received and dairy products returned relatively.

TABLE XLVI.—Giving Protein Received and Products Returned Daily per 1000 Pounds Live Weight.

GROUP	Weight	Protein	Milk	Per Cent Fat	Butter Fat	Solids Not Fat
I	890	2.29	31.20	4.54	1.415	2.671
II	909	1.85	33.99	3.80	1.280	2.811
III	846	1.56	31.72	4.40	1.397	2.768

The cows in Group I returned 31.20 pounds of milk, those in Group II 33.99 pounds and Group III 31.72 pounds, but since the milk yielded by Group I contained 4.54 per cent butter fat, that of Group II 3.8, and Group III 4.4, comparison cannot be made in yield of milk. If account is taken of the fat content it is found that 31.20 pounds of milk testing 4.54 per cent fat are equivalent to 37.27 pounds testing 3.8 per cent fat, and to 32.19 pounds testing 4.4 per cent fat and that Group I made the greater return. But since the excess of yield of Group I over II is 15 times greater than its yield is over Group III the discrepancy in yield cannot be ascribed to a shortage of protein because Group III received less than Group II. In comparing the butter fat yielded by the three groups we find that Group I gave .235 more than Group II and .018 more than Group III. There was also a product of milk solids not fat which must be taken into account. It will be seen that when this product is made the basis, results are just reversed; that Group II yielded .14 of a pound more than Group I and .043 more than Group III; again showing that the difference in yield cannot be due to the difference in the protein fed.

A better comparison can be made by reducing the nutriment consumed daily by each group to a starch or carbohydrate equivalent by multiplying the ether extract by 2.4—see

Henry's Feeds and Feeding, Article 132—and adding the product to the sum of carbohydrates and protein, showing total nutriment consumed daily per 1000 pounds live weight, also multiplying the butter fat by 2.5 and adding the product to the solids not fat for total product daily, and giving the net nutriment required to a pound of total product.

TABLE XLVII.—Giving Pounds of Nutriment Consumed and Total Product Yielded Daily per 1000 Pounds Live Weight and Net Nutriment to a Pound of Total Product.

GROUP	Total Nutriment Daily	Total Product Daily	Nutriment to 1 lb of Product
I	16.88	6.208	1.46
II	16.28	6.011	1.41
III	16.88	6.260	1.45

By this it is clearly shown that the three groups yielded dairy products in proportion to the nutriment available for product, and not according to protein supply, and that the amount of nutriment required to a pound of total product depended upon the ratio of butter fat to milk solids not fat.

The following table gives the daily average ration fed during the three winters, reduced to a basis of 1000 pounds live weight; total nutrients and the Wolff standard:

TABLE XLVIII.—Giving in Pounds Average Daily Ration Fed, and the Wolff Standard.

YEAR	Nutrients Daily per 1000 lbs. Live Weight			Total Nutrients	Nutritive Ratio
	Protein	Carbo-hydrates	Ether Extract		
1895–6	2.63	12.44	.69	15.76	1:5.3
1894–5	2.09	13.03	.58	15.81	1:6.8
1901–2	1.90	13.33	.60	15.85	1:7.7
Wolff Standard	2.50	12.50	.40	15.40	1:5.3

Comparing the rations fed during the winters 1894–5, 1895–6 and 1901–2 with the Wolff Standard we find little difference so far as total digestible matter is concerned; the rations exceeding it by about .4 of a pound. They contain about 50 per cent more ether extract. The carbohydrates also exceed those given in the standard, except for the win-

ter 1895–6 when they fell slightly below it, but this was more than made good by the excess of protein. In the protein we find the greatest variation; that fed during the winter of 1901–2 falling .6 of a pound below the Wolff Standard while one of the groups had .65 of a pound less and another .94 of a pound short. The uniformity in total nutrients used, is especially noteworthy from the fact that the cows were not fed by the standard, but simply according to each animal's needs, so far as amount of food consumed was concerned. Each cow was fed to her full limit and shows that Wolff's finding in this respect was wonderfully in accord with the average needs of cows. The apparent defect in the Wolff Standard is in the amount of protein prescribed, and not being applicable to the needs of the individual cow.

TABLE XLIX.—Giving Net Nutrients to a Pound of Milk, and the Lehmann Factors.

Net Nutrients	1895–6	1894–5	1901–2	Lehmann Factors
Protein Daily	2.63	2.09	1.90	
Protein to 1 lb. Milk	.0755	.0510	.0375	.0818
Carbohydrates to 1 lb. Milk	.2082	.2211	.1969	.2400
Ether Extract to 1 lb. Milk	.0224	.0177	.0156	.0180
Total Net Nutrients	.3061	.2898	.2500	.3398

Comparing the protein and other nutrients consumed to a pound of milk yielded with that prescribed in the Lehmann standard, it is found that each winter the cows used less of each nutrient than the standard provides; and that in applying the two standards, that formulated by Wolff comes nearer the average requirements. The Lehmann standard seems specially faulty in the assumption that it requires .081 of net protein to a pound of milk, and in not recognizing that nutrient requirements vary with the quality of the milk yielded.

To make further comparisons in regard to the nutrients required in milk production a table is submitted giving the net nutrients used to a pound of butter fat yielded, the daily average yield of milk and butter fat and the daily average

gain or loss in body weight during the three periods under review.

TABLE L.—Giving Net Nutrients to a Pound of Butter Fat, and Daily Yield of Products.

	1895-6	1894-5	1901-2
Protein used daily (in lbs.)	2.63	2.09	1.90
Protein to 1 lb. Butter Fat	1.920	1.244	.885
Carbohydrates to 1 lb. Butter Fat	5.295	5.395	4.652
Ether Extract to 1 lb. Butter Fat	.570	.434	.370
Total	7.785	7.073	5.907
Yield of Milk	25.71	26.09	28.40
Yield of Butter Fat	1.011	1.069	1.202
Daily Gain or Loss in Body Weight	+.20	+.12	—.13

Since no standards have taken butter fat and the quality of milk yielded into account, comparisons can only be made with results obtained during the three winter's work under review. When the cows had a daily allowance of 2.63 pounds of protein they returned a pound of butter fat to 1.92 of net protein; when they received daily 2.09 lbs. they returned a pound of butter fat to 1.244 of protein and when they received 1.90 they returned a pound of butter fat to .885 of protein and that it required 7.785 of net nutrients to a pound of butter fat when receiving 2.63 pounds of protein, 7.073 when receiving 2.09 and 5.907 when receiving 1.9 of protein; that is, the greater the protein supply, the more nutrients were used to a pound of butter fat yielded.

From the last sub-division of the table, it is seen that the winter the cows received 2.63 of protein they yielded daily 25.71 pounds of milk; when receiving 2.09 pounds of protein they gave 26.09 pounds and when receiving 1.9 of protein they gave 28.40 pounds. But since the milks differed in quality the yield is not comparable, but the daily yield in butter fat was 1.011, 1.069 and 1.202 respectively; that is, the yield of butter fat, as well as milk, was inversely to the protein supply. In examining the record as to the gain or loss in weight of cows it is shown that the winter they re-

ceived 2.63 pounds of protein they made a daily average gain of .2 of a pound, when receiving 2.09 of protein they gained .12 of a pound and when receiving 1.90 they lost .13 of a pound daily. Whether the decrease in gain the second year and the loss in weight the third year was due to the decrease in the protein supply or for some other cause does not appear. But it is possible, it might be said quite probable, that it was due to the difference in the ratio of grain to roughage. During the winter 1901-2 two-thirds of the nutrients in the rations were provided by the roughage, while during the winter 1894 5, just half the nutrients were in the roughage, and during the winter 1895-6 less than half. The fact that the loss in weight during the winter of 1901-2 occurred with all groups indicates that the cows were required to take so much of the daily ration in roughage that the nutrient content did not quite meet the requirements of the cows for the work they were doing and maintain their weight, though they ate to their full limit.

Reviewing the results obtained, it appears—

That the rations having a nutritive ratio of 1:7.7 and 1:9.7, respectively, were as effective in the production of milk, butter fat and milk solids as was the one having a nutritive ratio of 1:6.3.

That the protein required in milk production depends upon the quantity and quality of milk yielded.

That in the production of butter fat, actually more but relatively less protein and other nutrients were required to a pound of butter fat with cows giving milk containing a high per cent of fat than with those giving milk containing a low per cent of fat.

That in the production of milk solids less nutrients were required to a pound with cows giving milk having a low per cent of butter fat than with cows giving milk having a high per cent of fat.

It is not held that the decrease in the average daily yield and increased nutriment required to a given product was caused by the increase in protein supply, or that the increase in daily yield and decrease in nutriment required to a given product was caused by the decrease in protein supply,

but that a maximum yield is secured at a minimum cost of food by a proper adjustment of the amount of nutriment in the ration to the animal's needs for maintenance and for product yielded, and the bulk of the ration to its feeding capacity. An excess of nutriment in a ration does not seem to increase materially the flow of milk or yield of butter fat, but results in an increase in body weight and a relative decrease in dairy products; while a diminished nutriment supply resulted in a decreased gain in live weight and a relative increase in dairy products. The record for 1901-2 also shows that when a ration is short of nutriment because of excess bulk the cows maintained their flow at the expense of live weight, and that it was not because of the shortage of any particular component in the ration—for if such had been the case there would have been a decrease in the yield of milk because of lack of material for its production.

4. INFLUENCE OF STAGE OF LACTATION ON NUTRIMENT REQUIREMENTS.

In our feeding practice the general rule is to give the cows all they will eat up clean, and if a cow shows a desire for more feed it must not be granted until it has been manifested for a week. This is done because a cow will, for a few days, take more than her system can digest and assimilate, so under this rule with its restrictions cows seldom get more than they really need. And it is quite likely that by its strict enforcement it occasionally happens that a cow will shrink in milk because of a shortage of nourishment, but this is not so serious a matter as to cause a cow to go off her feed because of an excess of nutriment. It is not claimed that the cows are fed just right. To be frank we do not know yet the best way to feed each cow, but we are trying to learn and hope in time to succeed. To illustrate the results that are secured from week to week under the methods employed, tables are submitted giving the daily averages of a number of weeks' feeding, covering different stages of the period of lactation.

The following table gives the weekly weight, the nutrients consumed daily, yield of milk, butter fat, and total solids and also the nutrients required to one pound of butter fat and one of total milk solids after deducting for maintenance .78 of a pound per one hundred pounds live weight.

TRUST, CALVED NOVEMBER 12, 1901.

TABLE LI.—Giving Weights, Nutrients Consumed and Products Yielded from 1st-11th Week of Lactation.

Week	Weight	Nutrients Daily			Product Yielded			Nutrients to 1 lb.	
		Protein	C. H.	Fat	Milk	Butter Fat	Total Solids	Butter Fat	Total Solids
1st	925	1.408	8.61	.42	30.98	1.452	4.455	2.22	.72
2nd	875	1.899	9.69	.51	39.97	1.817	5.484	2.90	.96
3rd	825	1.814	8.84	.47	35.41	1.750	4.866	2.68	.96
4th	802	1.814	8.84	.47	30.91	1.708	4.411	2.85	1.10
5th	797	1.846	9.20	.47	32.00	1.558	4.342	3.40	1.22
6th	795	1.878	9.55	.47	32.87	1.573	4.444	3.62	1.28
7th	785	1.977	10 62	.52	33.50	1.544	4.208	4.57	1 58
8th	785	1.977	10.62	.52	32.72	1.531	4.415	4.57	1.58
9th	795	2.015	11.05	.53	33.77	1.487	4.272	4.97	1.73
10th	785	2.015	11.05	.53	32.76	1.610	4.439	4.64	1.68
11th	785	2.114	12.11	.57	32.16	1.377	4 075	6.30	2.12
Average...	814	1.877	10.01	.50	33.37	1.591	4.494	3.79	1.34

At the beginning of her lactation the cow weighed 925 pounds and during the week she shrank 50 pounds in weight. She consumed daily of protein 1.408 pounds, of carbohydrates 8.61 pounds, and ether extract .42 of a pound. She gave 30.98 pounds of milk, 1.452 of butter fat and 4.455 pounds of milk solids and returned a pound of butter fat to 2.22 pounds of net nutrients and a pound of milk solids to .72 of a pound, that is, she returned more product than there was of available nutrients, and it therefore follows that she applied some of the substances she had stored in her body either for maintenance or for product. By further examining the table it is seen that as her weight decreased the nutrients required to a pound of product increased, and that as her weight decreased, her daily consumption of nutrients increased until by the eleventh week, when she had reached her normal working weight, 785 pounds, she took 2.114 of protein, 12.11 of carbohydrates, and .57 of ether extract, and gave 32.16 pounds of milk, 1.374 of butter fat and 4.075 of milk solids. By the eleventh week she had practically estab-

lished an equilibrium between the in-go of nutrients and out-go of dairy product. She was in good flesh when she calved, and having stored in her body a large excess of body fat and other substances, she was enabled for ten consecutive weeks to yield more dairy products than the food supply would, under normal conditions, produce. The sudden shrinkage the fourth week in milk flow cannot be accounted for, but an examination of the record of the herd would probably show. Her average daily loss in weight during the first 42 days was 3.33 pounds. The extra ten pounds in weight the 9th week was probably caused by drinking more than the ordinary amount of water the day previous.

The following gives a similar record of Pride, covering the first 11 weeks of her lactation.

PRIDE, CALVED NOV. 29th.

TABLE LII.—Giving Weight, Nutrients Consumed and Products Yielded from 1st-11th Week of Lactation.

Week	Weight	Nutrients Daily			Product Yielded			Nutrients to 1 lb.	
		Protein	C. H.	Fat	Milk	Butter Fat	Total Solids	Butter Fat	Total Solids
1st	847	1.309	9.42	.47	29.74	1.483	4.288	3.09	1.07
2nd	825	1.322	9.55	.47	31.47	1.497	4.308	3.28	1.14
3rd	822	1.468	10.27	.51	30.14	1.458	4.198	4.00	1.39
4th	805	1.486	10.40	.50	32.06	1.461	4.213	4.18	1.45
5th	782	1.486	10.40	.50	31.30	1.423	4.116	4.42	1.49
6th	770	1.512	10.69	.51	32.01	1.357	4.094	4.94	1.64
7th	762	1.512	10.69	.51	30.78	1.407	4.124	4.81	1.64
8th	765	1.512	10.69	.51	30.24	1.323	4.019	5.10	1.68
9th	767	1.512	10.69	.51	29.10	1.228	3.925	5.48	1.71
10th	757	1.512	10.69	.51	28.76	1.270	3.819	5.36	1.78
11th	747	1.512	10.69	.51	28 28	1.241	3.684	5.54	1.86
Average...	786	1.467	10.38	.50	30.35	1.368	4.071	4.104	1.387

Pride weighed 847 pounds at the beginning of her lactation, received daily the first week 1.309 of protein, 9.42 pounds of carbohydrates and .47 of a pound of ether extract and gave 29.74 pounds of milk, 1.483 of butter fat and 4.288 milk solids, and returned a pound of butter fat to 3.09

pounds of net nutrients and a pound of milk solids to 1.07 pounds of nutrients. Her decrease in weight was more gradual and continued during the 11 weeks when she had lost 100 pounds. She did not sacrifice so much in weight in any one week as did Trust, nor did she yield products so much in excess of nutrients consumed. This was due to her temperament—not being so pronounced a dairy type. She is not as great a feeder as Trust and after the 5th week had reached her normal ration. As her weight decreased the nutrients required to a pound of product increased, but she had not by the close of the 11th week reached an equilibrium between the in-go of nutrients and out-go of product, for under normal conditions it requires over 6 pounds of nutrients to a pound of butter fat and about 2.45 to a pound of milk solids. During the 77 days covered by the record she lost on an average 1.4 pounds per day and had not reached her normal working weight.

EUROMA, CALVED OCT. 16.

TABLE LIII.—Giving Nutrients Consumed and Products Yielded from 5th-18th Week of Lactation.

Week	Weight	Nutrients Daily			Product Yielded			Nutrients to 1 lb	
		Protein	C. H.	Fat	Milk	Butter Fat	Total Solids	Butter Fat	Total Solids
5th	795	1.760	9.57	.49	23.87	1.348	3.650	4.18	1.54
6th	807	1.847	10.53	.52	24.36	1.390	3.734	4.75	1.76
7th	812	1.847	10.53	.52	23.73	1.336	3.635	4.91	1.80
8th	787	1.847	10.53	.52	22.94	1.304	3.521	5.12	1.89
9th	792	1.792	9.95	.49	22.06	1.311	3.457	4.62	1.75
10th	800	1.824	10.30	.49	21.31	1.283	3.409	4.97	1.87
11th	787	1.824	10.30	.49	21.38	1.188	3.151	5.45	2.05
12th	772	1.850	10.59	.50	21 38	1.101	2.999	6.28	2.31
13th	772	1.850	10.59	.50	21.76	1.126	3.179	6.14	2.11
14th	777	1.850	10.59	.50	21.94	1.150	3.221	5.98	2.10
15th	787	1.850	10.59	.50	21.21	1.193	3.211	5.70	2.11
19th	785	1.850	10.59	.50	20.93	1.198	3.185	5.69	2.10
17th	777	1.850	10.59	.50	20.56	1.167	3.109	5.87	2.21
18th	782	1.850	10.59	.50	21.24	1.196	3.224	5.72	2.12
Ave.	789	1.835	10.42	.50	22 05	1 235	3.334	5.34	1.98

Euroma came in four weeks before the feeding experiment began, so we have here a record covering a period from the 5th to the 19th week of lactation, leaving off the greater portion of the natural "milking down" period, so there are no such marked changes in weight as was shown in the tables preceding it. As the period of lactation advanced the nutrients required to a pound of product increased and during the 14 weeks she used on an average 5.34 pounds of nutrients to a pound of butter fat, while Pride required 4.104 and Trust 3.79. She returned a pound of milk solids to 1.98 pounds of nutrients, while Pride required 1.39 and Trust 1.34. This difference seems to be due to the difference in the rate of decrease of body weight and with Euroma, also, to the farther advance in lactation.

DORRIT, CALVED SEPT. 16, 1901.

TABLE LIV.—Giving Nutrients Consumed and Products Yielded from 9th-23rd Week of Lactation.

Week	Wt.	Nutrients Daily			Products Yielded			Nutrients to 1 lb.	
		Protein	C. H.	Fat	Milk	Butter Fat	Total Solids	Butter Fat	Total Solids
9th	897	2.111	12.03	.61	25 60	1.489	3.953	5.23	1.96
10th	902	2.111	12.03	.61	24.81	1.477	3.821	5.23	2.02
11th	902	2.111	12.03	.61	24.81	1.477	3.821	5 23	2.02
12th	897	2.012	10.97	.56	21.84	1.311	3.407	4.99	1.92
13th	892	2.012	10.97	.56	23.00	1.337	3.501	4.92	1.87
14th	900	2.044	11.33	.56	22.66	1.344	3.474	5.14	1.99
15th	912	2.076	11.64	·56	22.50	1.258	3.391	5.70	2.11
16th	905	2.076	11.64	.56	22 31	1 280	3.307	5.64	2.18
17th	895	2.076	11.64	.56	21.96	1.180	3.189	6.18	2.28
18th	895	2.114	12.11	.57	22.61	1.233	3.233	6.34	2.41
19th	892	2.114	12.11	.57	22.40	1.167	3.163	6.71	2.47
20th	897	2.114	12.11	.57	22.37	1.176	3.302	6.63	2.36
21st	910	2.114	12.11	.57	21.33	1.137	3.138	6.77	2.45
22nd	910	2.114	12 11	.57	21.17	1.148	3.135	6.70	2.45
23rd	910	2.114	12.11	.57	21.70	1.168	3.181	6.59	2.41
Ave.	901	2.085	11.78	.57	22.59	1.265	3.371	5.85	2.19

Dorrit calved September 16th so she was in her 9th week of lactation on the 11th of November when the feeding experiment began, and the record covers her work from the be-

ginning of the 9th week to the close of the 23rd week. By taking the average weight of the first four weeks of the record and the last four, we find that she weighed 10 pounds more two weeks before the record closed than she did two weeks after it began, being a daily average gain in weight of .10 of a pound; that she required only 5.23 pounds of nutrients to a pound of butter fat the 9th week, and the 18th, when an equilibrium had been obtained between the food consumed and products yielded, she required 6.34 pounds and for milk solids 2.41 pounds. From the 18th to the end of the 23rd she required on the average more than the normal amount, because some was diverted to gain in weight, though the excess was very slight. It will be observed that there was a decrease in the nutrients in the rations fed during 6 weeks of the experiment, this is the case with all the cows in the herd and was an unfortunate occurrence for the character of the work in hand. It was caused by introducing beet pulp in the ration and resulted in a depression in both yield of milk, per cent fat content, and per cent of total milk solids.

TABLE LV.—Giving Record of Klondike from the 29th-42nd Week of Lactation.

Week	Weight	Nutrients Daily			Product Yielded			Nutrients to 1 lb	
		Protein	C. H.	Fat	Milk	Butter Fat	Total Solids	Butter Fat	Total Solids
29th	952	1.330	11.56	.55	22.37	1.138	3.080	5.25	1.95
30th	975	1.429	12.62	.60	22.88	1.144	3.123	6.16	2.26
31st	972	1.429	12.62	.60	22.08	1.100	3.009	6.43	2.35
32nd	967	1.330	11.56	.55	23.58	1.173	3.183	5.03	1.85
33rd	952	1.362	11.92	.55	22.41	1.177	3.142	5.45	2.04
34th	942	1.426	12.27	.55	22.48	1.117	3.186	6.17	2.16
35th	940	1.426	12.27	.55	23.00	1.084	2.972	6.38	2.33
36th	945	1.426	12.27	.55	21.33	1.060	2.860	6.49	2.40
37th	940	1.432	12.70	.56	22.71	1.086	3.070	6.78	2.40
38th	937	1.432	12.70	.56	23.24	1.161	3.188	6.34	2.32
39th	947	1.432	12.70	.56	22.88	1.176	3.128	6.21	2.33
40th	947	1.420	12.56	.56	22.23	1.094	3.039	6.53	2.35
41st	950	1.420	12.56	.56	23.14	1.144	3.112	6.23	2.29
42nd	942	1.432	12.70	.56	23.48	1.153	3.221	6.37	2.28
Ave.	951	1.409	12.36	.56	22.49	1.129	3.094	6.12	2.23

The record of Klondike affords most excellent data for the study of nutrient requirements near the close of a year's lactation. The food given was quite constant as to quantity, showing that the bulk of the ration fairly met her feeding capacity, and that there was no shrinkage in the flow of milk or yield of butter fat, shows that there was no serious lack in nutriment, though there was a slight shortage to the 37th week, as is shown by the weekly weighings. Her average weight the first four weeks was 966, and the last four, 946, being a loss of 20 pounds in 70 days. The nutrient requirements to a pound of butter fat and milk solids were as uniform as could be expected, in view of the constant variations that occur in the per cent fat in milk. During the 29th, 32nd and 33rd week there was a decrease in the nutrients to a pound of butter fat and milk solids, but this was due to a reduction in the feed. The food was increased during the 30th and 31st week and decreased the 32nd. With the increase of feed she decreased in product and the 32nd week she gained in milk and butter fat on the diminished ration, but this was the residual effect of the over-supply of nutriment the week previous.

A similar result is observed with Duchess the 70th and 71st week of lactation. There was a decrease in butter fat the 33rd, when the feeding of beet pulp began, to the close of the 36th week. This decrease was checked by adding 6 pounds of pulp to the ration; but when it became necessary to reduce the ration the 40th week, a diminuation in butter fat again occurred, but with a gain in weight. A careful study of the food supply, product yielded, and nutrients required to a given product, shows that the food provided was very close to her actual requirements. Special attention is invited to the daily protein supply, being on an average 1.409 pounds and leaving only .743 of a pound of protein available for product and she returned a pound of milk to .03 of protein, while the Wolf Lehmann standard prescribes .08. The average test of the milk during the time covered by the record was 5 per cent. Table XXVI in the 2nd Article gives the nutrients used to a pound of 5 per cent milk .053 protein, .247 corbohydrates and .018 of ether extract.

Klondike returned a pound of milk to .03 protein, .253 carbohydrates and .020 of ether extract. She received .303 lbs. net nutrients to a pound of milk and lost .29 of a pound daily in body weight, while the table referred to prescribes .318 of a pound of net nutrients to a pound of milk. For the present it is not recommended that cows should be fed on a ration having so little protein, that is, with a nutritive ratio of 1:10, for it might ultimately cause a depression in milk giving functions and deterioration in dairy temperament in the off spring. However, as yet no ill effects have been manifested from feeding the wide rations. The most surprising feature is a shrinkage in weight with wide rations as shown in Table L.

DUCHESS.

TABLE LVI.—Giving Nutrients Consumed and Products Yielded by Duchess from her 58th-71st Week of Lactation.

Week	Weight	Nutrients Daily			Product Yielded			Nutrients to 1 lb	
		Protein	C.H.	Fat	Milk	Butter Fat	Total Solids	Butter Fat	Total Solids
58th	822	1.254	9.62	.45	13.83	.856	2.167	5.74	2.27
59th	832	1.509	10.63	.53	13.36	.871	2.160	7.09	2.86
60th	830	1.254	9.62	.45	13.53	.844	2.147	5.75	2.26
61st	835	1.254	9.62	.45	13.53	.827	2.117	5.82	2.27
62nd	845	1.267	9.76	.45	13.33	.871	2.146	5.61	2.28
63rd	850	1.286	9.98	.45	12.41	.798	1.979	6.37	2.57
64th	835	1.231	9.39	.42	12.77	.784	1.966	5.78	2.30
65th	820	1.231	9.39	.42	13.48	.741	1.944	6.26	2.39
66th	807	1 257	9.68	.43	13.52	.741	1.974	6.74	2.53
67th	812	1.257	9 68	.43	13.63	.684	1.919	7.36	2.62
68th	822	1.257	9.68	.43	14.18	.788	2.147	6.29	2.31
69th	825	1.257	9.68	.43	13.87	.770	2.018	6.41	2.45
70th	822	1.512	10.69	.51	14.23	.773	2.060	8.15	3.06
71st	825	1.257	9.68	.43	15.17	.854	2 278	5.78	2.17
Ave.	827	1.292	9.79	.45	13.63	.800	2 073	6.35	2.45

The heifer Duchess aborted and was in her 58th week of lactation when the feeding experiment began. Her average weight during the first three weeks was 828 pounds, and the last three, 824 pounds, being a decrease of only 4 pounds, taking the three first and three last weighings as a basis. There was, however, quite a change in her weight, gradually increasing to the 63rd week and then decreasing to the 66th week and this was probably due to the reduction in her feed,

for when it was increased she regained her weight. The decrease in total nutrients at this stage of the experiment was due to the reduction in silage and at attempt to replace it it with beet pulp. The change in the amount of nutriment was due to the addition of 4 pounds of pulp and resulted in an increase in the flow of milk, but there was an abnormal depression in the fat content which raised the nutriment used to 7.36 pounds to a pound of butter fat. The increase in nutriment the 59th and the 70th week was due to an error in feeding 7 pounds of grain instead of 5, the amount assigned to her. Duchess and Leeoma were the only cows in the herd that were fed according to yield of milk and butter fat, and the result was that both returned butter fat and milk solids for the normal amount of nutriment regardless of advanced stage of lactation. Duchess returned a pound of butter fat to 6.35 pounds of nutriment, while Leeoma required .14 less; though this would naturally follow because Duchess' milk contained more solids not fat, and on this account she was enabled to return a pound of total solids to 2.45 of nutriment, while Leeoma used 2.47.

LEEOMA, ABORTED AUG. 3, 1900.

TABLE LVII.—Giving Nutrients Consumed and Products Yielded from 119th-132nd Week of Lactation.

Week	Weight	Nutrients Daily			Product Yielded			Nutrients to 1 lb	
		Protein	C. H.	Fat	Milk	Butter Fat	Total Solids	Butter Fat	Total Solids
119th	895	1.126	9.12	.41	8.90	.610	1.523	6.03	2.41
120th	902	1.126	9.12	.41	9.06	.623	1.565	5.82	2.32
121st	902	1.126	9.12	.41	8.88	.604	1.519	6.00	2.39
122nd	900	1.039	8.18	.38	8.77	.607	1.499	4.25	1.72
123rd	900	1.139	9.26	.41	8.51	.598	1.484	6.34	2.55
124th	902	1.158	9.48	.41	8.27	.583	1.420	6.89	2.82
125th	890	1.071	8.54	.38	8.47	.541	1.355	5.64	2.25
126th	882	1.103	8.89	.38	8 31	.554	1.372	6.30	2.55
127th	895	1.129	9.18	.39	8.61	.546	1.398	6.81	2.66
128th	900	1.129	9 18	.39	8.76	.553	1.387	6.65	2.65
129th	905	1.129	9.18	.39	8.93	.580	1.456	6.27	2.50
130th	902	1.129	9.18	.39	8.94	.591	1.476	6.21	2.48
131st	887	1.257	9.68	.43	9.11	.587	1.518	7.57	2.93
132nd	890	1.129	9.18	.39	9.44	.604	1.558	6.22	2.41
Ave.	896	1.128	9.09	.40	8.78	.584	1.467	6.21	2.47

The foregoing table covers the record of the daily average for each week beginning with the 119th week of lactation to the close of the 132nd week. While there was some variation in the weight from week to week there was no marked gain or loss. Twice her feed was reduced, the 122nd and 125th, the latter time it covered two weeks. The 127th it was again raised and for 28 consecutive days there was no change. It was then raised and the week following it was again found necessary to reduce it. She maintained her flow in milk but there was a slight decrease in butter fat. When her feed was lowered she used less than the normal amount of nutrients, about 6 pounds, to a pound of butter fat yielded. During the 131st week of lactation when her feed was raised, she returned a pound of fat to 7.57 pounds nutriment and did not increase in yield of fat, but the week following there was a slight increase. Notwithstanding that the record covered a period from the 119th to the 132nd week of lactation she required only 6.21 pounds of nutriment to a pound of butter fat and 2.47 to a pound of milk solids being the normal amount required by cows when no change in body weight takes place.

BESS, CALVED JULY 9, 1897.

TABLE LVIII.—Giving Nutrients Consumed and Products Yielded from 237th-248th Week of Lactation.

Week	Weight	Nutrients Daily			Product Yielded			Nutrients to 1 lb	
		Protein	C. H.	Ether Ex.	Milk	Butter Fat	Total Solids	Butter Fat	Total Solids
237th	1050	1.770	10.86	.57	14.00	.690	1.96	7.26	2.60
238th	1065	1.716	11.00	.55	12.77	.661	1.83	7.51	2.70
239th	1072	1.897	12.09	.58	14.30	.690	1.98	8.99	3.53
240th	1075	1.897	12.08	.58	14.93	.723	2.03	8.54	3.04
241st	1075	1.897	12.09	.58	14.51	.696	1.99	8.87	3.10
242nd	1077	1.897	12.08	.58	14.97	.698	2.05	8.54	3.00
243rd	1085	1.873	11.70	.57	15.48	.718	2.13	7.91	2.66
244th	1085	1.873	11.70	.57	14.14	.698	1.96	8.11	2.90
245th	1105	2.182	12.75	.63	13.41	.687	1.90	10.11	3.65
246th	1122	1.940	11.34	.56	14.17	.703	1.93	7.22	2.63
247th	1125	2.142	12.55	.63	15.56	.711	2.12	9.20	3.08
248th	1130	1.904	11.15	.56	16.40	.736	2.18	6.52	2.20
Ave.	1088	1.915	11.78	.58	15.39	.701	2.00	8.01	2.89

In the record of Bess data are presented covering a period from the beginning of the 237th to the close of the 248th week of lactation. It is not expected that in a cow, farrow so long, the lacteal functions would be very active, or that on full feed she would make normal return in dairy products. At the beginning of the record presented, she weighed 1050 pounds and at the close 1130, being a daily gain of 1.04. Her daily yield of butter fat was .701 of a pound and 2 pounds of milk solids. She returned a pound of fat to 8.01 pounds of nutriment and a pound of milk solids to 2.89 pounds. She evidently received more nutriment than she needed for the work she was doing in the dairy and placed the surplus to her credit in gain in weight, though she made a slight gain in flow of milk, and yield of butter fat and milk solids. There was no attempt to feed her according to her yield, but she received full feed for the group she happened to be with during the winter of 1900-1, and the same data are used in different form in Bulletin 71. The ration was small in bulk and strong in nutriment when she was so fed that she was satisfied with the bulk; by the end of the week she would show signs of going off her feed because there was too much nutriment; when it was decreased in quantity by the end of the week she wanted more because it lacked in bulk, though the nutriment was ample. This made her receive a light ration one week and a heavier one the next, as is shown by the latter part of the table. Bess dropped her calf when she was two years old and this was in the fifth year of lactation.

TABLE LIX.—Giving Stage of Lactation, Loss or Gain in Weight, Yield of Butter Fat and Total Solids and Net Nutriment to 1 lb. of Butter Fat and 1 lb. of Milk Solids.

	Time of Lactation		Daily Gain or Loss in Weig't	Daily Yield		Net Nutriment to 1 Lb.	
	From Week	To Week		Butter Fat	Total Solids	Butter Fat	Total Solids
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Trust	1st	11th	—2.00	1.591	4.494	3.79	1.34
Pride	1st	11th	—1.40	1.368	4.071	4.10	1.39
Euroma	5th	18th	— .30	1.235	3.334	5.34	1.98
Dorrit	9th	23rd	+ .10	1.265	3.371	5.85	2.19
Klondike	29th	42nd	— .30	1.129	3.094	6.12	2.23
Duchess	58th	71st	— .05	.800	2.073	6 35	2.45
Lecoma	119th	132nd	.00	.584	1.467	6.21	2.47
Bess	237th	248th	+1.04	.701	2 000	8.01	2.89

During the first eleven weeks one cow returned a pound of butter fat to 3.79 pounds of net nutriment, and lost daily in weight 2 pounds, while another cow required 4.10 pounds and lost 1.4 pounds daily in weight. That from the 5th to 18th week one required 5.34 pounds of nutriment to a pound of butter fat and shrunk in weight .30 of a pound daily; another from the 9th to the 23rd weeks required 5.85 pounds of net nutriment to a pound of butter fat and gained .10 of a pound daily; another from the 29th to the 42nd week returned a pound of butter fat to 6.12 pounds of available nutriment; that from the 29th to the 132nd week there was little change in nutriment requirements to a pound of butter fat, the range being from 6.12 to 6.35 pounds, and that if a cow is fed more nutriment than she needs normally for dairy products she will convert the surplus to gain in weight. During the early stages of lactation she may return more than twice the product that the net nutriment would provide for, under normal working condition of body weight. If a cow is in good condition when she drops her calf, the yield is largely in excess of the nutriment supply in the ration, and will be in excess until she has milked down to normal weight, after which the nutriment required to a pound of butter fat will remain quite constant for an indefinite time under proper management.

It has been shown that the rate of decrease in live weight when cows are fresh in milk varies with different individuals, and that it gradually decreases as the period of lactation advances. Also that the excess of yield in dairy products decreases from week to week until the yield, especially of butter fat, is fully provided for by the available or net nutriment consumed; but that the excesss of yield in total solids is prolonged for a time after a stationary body weight is reached. To further illustrate this peculiar phenomena, and to show the average rate of increase in nutriment requirements for a pound of butter fat and a pound of total milk solids, as the lactation period advances, a table is submitted showing the average weight after calving of 15 cows, their average weekly weight for the first nine weeks, their average daily yield of butter fat for each week and net nutriment to

a pound of butter fat and total solids; also the nutriment requirement for the three cows that were far advanced in lactation.

TABLE LX.--Giving Average Weekly Weight of 15 Cows. Average Daily Yield of Butter Fat and Average Net Nutriment Required to 1 Pound of Butter Fat and 1 Pound of Total Solids.

Lactation Weeks]	Average Weight	Butter Fat Daily	Net Nutriment to 1 lb.	
			Butter Fat	Total Solids
1st	966	1.083	3 24	.92
2nd	917	1.369	3.60	1.13
3rd	900	1.325	4.24	1.35
4th	877	1.295	4.71	1.51
5th	873	1.259	5 38	1.63
6th	863	1.232	6.07	1.72
7th	865	1.202	6.18	1.75
8th	858	1.159	6 24	1.81
9th	853	1.120	6.25	1.89
1 Cow 29th to 42nd.....	951	1.129	6.12	2.23
1 Cow 58th to 71st.....	827	.800	6.35	2.45
1 Cow 119th to 132nd.....	896	.584	6.21	2.47

The cows weighed on an average 966 pounds at the beginning of lactation and 853 the 9th week being an average daily loss per cow of 2 pounds. The first week they returned a pound of butter fat to 3.24 pounds net nutriment, and a pound of milk solids to .92 of a pound, and as the cows decreased in weight the nutriment required to a given product yielded increased up to the 9th week when a pound of butter fat was returned to 6.25 pounds of nutriment, but then the nutriment required to a pound of total solids had reached only 1.89 pounds, showing that while an equilibrium had been reached between the daily nutriment supply and butter fat yielded, such was not the case with reference to the nutriment required to a pound of milk solids, for as will be seen by comparing it with the amount required by the three cows, ranging in lactation from the 29th to the 133rd week the normal requirement is 2.4 pounds.

Again referring to Table LI, to show the product re-

turned to net nutriment available for product by the cow Trust, the following table is given showing the daily average consumption of total nutriment during each week for 11 consecutive weeks, the nutriment needed daily for maintenance, that available for product, total product yielded daily and nutriment to one pound of product. The *total nutriment* consumed daily is obtained by multiplying the ether extract taken daily by 2.4 and adding the product to the digestible protein and carbohydrates taken daily; and the *total product* yielded by multiplying the butter fat yielded by 2.5 and adding the product to the milk solids not fat yielded daily.

While butter fat may have a uniform energy value, cows differ with reference to the per cent fat yielded to solids not fat, and so even total solids cannot be employed as a correct measure of product yielded. It is for this reason that an attempt is made to reduce the two products, solids fat and solids not fat, to a common energy value by the method stated.

TABLE LXI.—Showing Disposition Made of Nutriment Consumed by Trust During a Period of 77 Days.

Week	Total Nutriment Daily	Nutriment for Maintenance	Nutriment for Product	Total Product Daily	Lbs. of Net Nutriment to 1 lb. of Total Product
1st	11.026	7.215	3.811	6.633	.57
2nd	12.813	6.525	6.388	8.209	.77
3rd	11.782	6.455	5.327	7.491	.71
4th	11.782	6.256	5.526	5.973	.92
5th	12.174	6.217	5.957	6.679	.89
6th	12.556	6.201	6.355	6.803	.93
7th	13.845	6.123	7.722	6.524	1.08
8th	13.845	6.123	7.772	6.711	1.15
9th	14.337	6.201	8.136	6.502	1.25
10th	14 337	6.123	8.214	6.854	1.19
11th	15.592	6.123	9.469	6.140	1.54
Average...			6.788	6.774	1.00

Special attention is invited to the gradual increase from week to week of the amount of nutriment consumed daily as the period of lactation advanced, except the second week,

when she received more than she could take any of the four weeks following, showing that she was over-fed the second week; that she varied considerably from week to week in the daily average of total product yielded; that during the first week she yielded 1 pound of product to .57 of a pound of nutriment, being nearly twice as much product as she had nutriment available for product; that for six consecutive weeks the product yielded was in excess of the available nutriment; that during the 77 days, covered by the table, she had available for product 522.7 pounds of nutriment and yielded 521.6 pounds of product; that the daily average of net nutriment was 6.788 pounds; the daily average of product yielded was 6.774, and returned a pound of product to practically a pound of net nutriment.

While it is clearly shown that the cow was enabled to make greater return in butter fat to nutriment consumed, because of having stored surplus body fat during the time that she was dry, the question suggested is, was it economical, considering the extra nutriment required, to provide for the gain in body fat sacrificed. By referring to table LX it will be seen that it required about 6.25 pounds of net nutriment to a pound of butter fat, where cows had been in milk for some considerable time, and were neither gaining nor losing in body weight. During 77 days Trust yielded 121.8 pounds of butter fat and had during that time 522.7 pounds of net nutriment, which, under normal conditions, would have provided for 83.6 pounds of butter fat. But she lost in body weight 140 pounds and produced 38.2 pounds of butter fat above the normal yield, losing 3.66 pounds in body weight to each pound of butter fat yielded in excess of the amount provided for in the net nutriment.

By making similar calculations from table LII to show the influence on yield of dairy products by decrease in weight of body, the following table is submitted.

TABLE LXII.—Showing Disposition Made of Nutriment Consumed During a Period of 77 days by Pride.

Week	Total Nutriment Daily	Nutriment for Maintenance	Nutriment for Product	Total Product Daily	Lbs. of Net Nutriment to 1 lb. of Total Product
1st	11.857	6.607	5.250	6 511	.81
2nd	12.000	6.435	5.565	6.553	.88
3rd	12.962	6.412	6.550	6 380	1.02
4th	13.086	6.279	6.807	6.404	1.06
5th	13.086	6.100	6.986	6 250	1.10
6th	13.426	6 006	7.420	6.129	1.21
7th	13.426	5.944	7.582	6 334	1.19
8th	13.426	5.957	7.469	6.003	1.24
9th	13.426	5.983	7.443	5.767	1.29
10th	13.426	5.903	7.521	5.724	1.31
11th	13.426	5.826	7.600	5.545	1 37
Average...			6.926	6.145	1.127

In the performance of Pride it can be again seen that cows do not take full rations in the early part of the lactation period, and that when a cow's temperament is such that she does not decrease so rapidly in weight of body, she will more quickly reach a stage when she will take a full ration as did Pride the 6th week, but while she received a full ration the last six weeks, she had not milked down to her normal working weight by the 11th, and was then returning a pound of total product to 1.37 pounds of nutriment, while at the same stage of lactation Trust used 1.54 pounds. By referring to table LII it will be seen that she decreased in weight of body more slowly and that she used more nutriment to a given product yielded, and that the *rate* of decrease in weight of body has a bearing on the amount of nutriment required in milk production. During the 77 days she had 533.3 pounds of nutriment available for product which under normal conditions would have provided for a yield of 85.3 pounds of butter fat. But she lost 100 pounds in body weight and produced 105.3 pounds of butter fat, being 20 pounds more than the nutriment provided for. She therefore sacrificed 5 pounds in live weight to each pound of butter fat yielded in excess of that provided for by the nutriment consumed.

It is not expected that by making any one product the basis of calculation the exact results from decrease in weight of body can be shown, because dairy products have not a common energy value, and because all the solids yielded in milk are derived either from the nutriment consumed or from the substances stored in the body, but it would seem to be more in accord with the natural order of things that nearly all the milk solids are the direct product of the nutriment then taken, and the maintenance and energy expended are chargeable at least in part to oxidation of body tissue.

Making similar calculations from the records of the cows Klondike, Duchess and Leeoma, that were made from the records of Trust and Pride, it can be approximately determined what the nutriment requirements are where no material change in weight of body takes places.

TABLE LXIII.—Showing Total Nutriment Daily, Nutriment Available for Product and Nutriment Required to a Pound of Total Product Yielded.

	Total Nutriment Daily	Nutriment Daily for		Total Product Daily	Lbs. of Net Nutriment to 1 lb. of Total Product
		Maintenance	Product		
Klondike	15.113	7.418	7.695	4.788	1.60
Duchess	12.162	6.451	5.711	3.273	1.74
Leeoma	11.178	6.989	4.189	2.343	1.78
Total	38.453	20.858	17.595	10.404	
Average	12.818	6.953	5.865	3.468	1.69

From this it is seen that it required from 1.60 to 1.78 pounds of nutriment to 1 pound of product. By referring to table LIX it will be seen that the cow Klondike was really loosing weight at the rate of about a quarter of a pound a day, and this had a noticeable influence on the nutriment she used to a pound of product. Her system had the alternative of using the full complement of nutriment required for maintenance and shrink in yield of dairy product, or maintain the yield and shrink in body weight, but it chose to give full return in dairy product and draw on body tissue to make good the shortage in the nutriment supply, showing how wonderfully responsive the dairy bred cow is to the demands of her lacteal functions.

The record of the cow Duchess gives a further illustration of the influence of change in body weight upon the return of

dairy products to food consumed. In her case, as may be seen by referring to table LIX, the slight daily loss of less than .1 of a pound in weight is reflected in the amount of nutriment required to a pound of product. There was doubtless a waste of nutriment during the 59th and 70th weeks of lactation because of the sudden increase in the rations fed during the two weeks. This is indicated by the fact that she stands charged in the table referred to, with 6.35 pounds of nutriment to 1 pound of butter fat yielded, while Leeoma required only 6.21.

Taking into account the changes in the weight of the cows referred to, it is quite evident that it requires about 1.75 pounds of available nutriment to produce 1 pound of product; that is, of the available nutriment, 43 per cent is expended in energy and 57 per cent is returned in the milk solids.

Of the total nutriment consumed daily approximately 54 per cent was required for maintenance, 19 per cent for energy and 27 per cent was returned in the milk solids.

Again taking the record of Trust during the first ten weeks of her period of lactation, showing the decrease in weight from week to week, the average daily nutriment available for product each week, the butter fat yielded, the normal daily yield, and average daily yield in excess, the compensatory yield by virtue of a daily loss in weight of 2 pounds is shown.

TABLE LXIV.—Showing Decrease in Weight of Trust, Daily Average of Net Nutriment, Yield of Butter Fat, Normal Yield and Excess.

Week	Weight	Net Nutriment Daily	Butter Fat Daily	Daily Normal Yield Butter Fat	Daily Excess Yield Butter Fat
1st	925	3 811	1.452	.609	.843
2nd	875	6.388	1.817	1.022	.795
3rd	825	5.327	1.750	.852	.898
4th	802	5.526	1.708	.884	.824
5th	797	5.957	1.558	.953	.605
6th	795	6.355	1.573	1.017	.556
7th	785	7.722	1.544	1.235	.309
8th	785	7.722	1.531	1.235	.296
9th	795	8.136	1.487	1.302	.185
10th	785	8.214	1.610	1.314	.296
Average...		6.516	1.603	1.042	.561

The first week the cow received daily 3.811 pounds of nutriment available for product and yielded 1.452 pounds of butter fat. It has been shown that the normal requirements for a pound of butter fat is 6.25 pounds of nutriment and on this basis the nutriment available for product provided for only .609 of a pound of butter fat and her daily yield was .843 of a pound in excess. During the 70 days covered by the table she received daily on an average 6.516 pounds of net nutriment and yielded 1.603 of butter fat—being a daily yield in excess of that provided for in the ration of .561 of a pound. Since she decreased in weight on an average 2 pounds per day, the excess yield of butter fat was .28 of a pound for each pound of body weight sacrificed, or a decrease of 3.57 pounds body weight to a pound of excess yield of butter fat.

The record of the 15 cows that came into milk from and after the 11th of November also gives some evidence in regard to the amount the daily yield of butter fat is increased by virtue of the milking down of body weight, and the relation between the daily decrease in weight and excess yield of butter fat.

TABLE LXV.—Showing Decrease in Weight, Daily Average Yield of Butter Fat, Normal and Excess Above Normal Yield.

Week	Weight	Net Nutriment Daily	Butter Fat Daily	Daily Normal Yield Butter Fat	Daily Excess Yield Butter Fat
1st	966	.....	.....	.....	.....
2nd	917	4.648	1.369	.744	.620
3rd	900	5.363	1.325	.858	.467
4th	877	5.989	1.295	.958	.337
5th	873	6.156	1.259	.985	.274
6th	863	6.500	1.232	1.040	.192
7th	865	6.390	1.202	1.022	.180
8th	858	6.511	1.159	1.042	.118
9th	853	6.535	1.120	1.045	.075
Daily Average.....		6.011	1.245	.962	.283

The cows received daily on an average 6.011 pounds of digestible matter available for product, and yielded daily 1.245 pounds of butter fat. The data already submitted shows that it requires 6.25 pounds of net digestible matter to a pound of butter fat, and upon this basis the nutriment provided daily was only enough for a daily yield of .962 of a pound butter fat, while the average daily excess yield per cow was .283 of a pound. Since the daily average loss in body weight per cow was 2 pounds, the daily compensatory yield by virtue of decrease in live weight was at the rate of .14 of a pound of butter fat per pound of decrease in weight of body, being a sacrifice of 7 pounds of live weight to 1 pound of butter fat yielded in excess of the yield provided for in the ration.

The following deductions are made from the data submitted:

1. During the early stages of the period of lactation cows lose rapidly in body weight; of 15 cows the average decrease per cow the first week was 49 pounds, and during 56 days there was a daily average loss per cow of 2 pounds.

2. During the time when the decrease in body weight takes place cows yield dairy product in excess of the amount provided for by the food consumed; the excess of yield depending upon the rate of loss in weight of body, in some instances it is more than twice the amount provided for by the available nutriment.

3. The excess yield of dairy products gradually decreases until about the 11th week when an equilibrium generally obtains between the nutriment consumed and dairy products yielded, though in this respect cows differ; those of a pronounced dairy temperament taking less time, while those not strong in dairy temperament decrease more slowly in weight and require more time to reach normal work in milk production. Before such equilibrium is reached the body fat and possibly other substances contribute directly or indirectly to product.

4. The normal net nutriment requirements to a pound of butter fat is approximately 6.25 pounds, with a slight increase by cows yielding milk containing a low per cent butter

fat, and less with cows giving milk containing a high per cent of butter fat.

5. The normal net nutriment requirements to a pound of milk solids yielded is approximately 2.4 pounds with a slight increase with cows yielding milk rich in butter fat and less with cows giving milk containing a low per cent of butter fat.

6. When the daily nutriment available for product and the products yielded daily are reduced to an approximate common value of energy, it is found that it requires about 1.75 pounds of available nutriment to 1 pound of product; that is, of the available nutriment, 43 per cent is expended in energy and 57 per cent is returned in the milk solids.

7. The daily yield of butter fat in excess of the nutriment supply, by virtue of an average daily loss per cow of 2 pounds in body weight, was .283 of a pound, being a sacrifice of 7 pounds in body weight to 1 pound of butter fat yielded in excess of that provided for in the ration.

8. When the normal working condition of body weight is reached, the nutriment required to a pound of butter fat and a pound of milk solids remains quite constant for an indefinite time under proper management.

ALFALFA. ITS CHEMICAL DEVELOPMENT. FEEDING VALUE AND DIGESTIBILITY.

*HARRY SNYDER AND J. A. HUMMEL.

INTRODUCTION.

The interest which has recently been manifested in alfalfa by farmers and stockmen throughout Minnesota has prompted this work. Much encouragement is being given the growth of this great forage plant by the discovery and

Figure 1.—Third crop Alfalfa, Aug. 28, on farm of Mr. A. B. Lyman, Excelsior, Minn.

*The details of this work have been carried out and the results prepared for publication by Mr. J. A. Hummel, Asst. Chemist. There has been a great deal of interest taken in alfalfa and it is believed that this bulletin will answer some of the numerous inquires that have been made regarding this crop.

H. SNYDER, Chemist.

introduction of varieties that seem to be hardy in our severe climate. Some of these varieties have been brought from certain localities in Turkestan, the climate of which resembles that of Minnesota. Alfalfa has been grown without difficulty in the region of Lake Minnetonka in this state, for thirty or more years. The seed of this variety was brought into the state by certain Germans, and is said to have come originally from Norway. This variety has been found to be perfectly hardy in that vicinity, and no doubt, will thrive throughout the state generally excepting possibly certain sections in the northern third of the state. Because of the encouragement thus offered, this work on alfalfa was undertaken with the object of determining its composition and feeding value when grown in Minnesota, its chemical development and draft upon the soil. It was also thought that the work might stimulate the interest already shown and bring before our farmers, the great possibilities of this forage plant.

Alfalfa or lucern, *medicago sativa*, is a native of Western Asia; it was early introduced into Southern Europe and later was taken to South America whence it found its way into Mexico and then to California and other western states. In the region south and west of the Missouri River, it found congenial conditions and has proved of immense value to farmers throughout that country.

Alfalfa belongs to the same family as clover, peas and beans, the legume family. The young plant, at first, has a single stem, but as this is cut off or grows older, it branches and forms a crown with many stems. The plant has a strong tap root with smaller lateral roots as feeders. This tap root goes deeply into the soil and finds moisture even when far below the surface. On the roots are found tubercles, or small nodules, (see figure 2), similar to those found on red clover roots, and by means of these tubercles, which are induced by bacteria, the plant is enabled to gather and use as plant food, free nitrogen of the air, so that in common with red clover and other members of this family, it not only has the power of storing up within itself large quantities of that valuable nitrogenous material protein, but by

Fig. 2.—Alfalfa roots, showing the nodules.

the accumulation of roots, it leaves the soil richer in this element than it was before producing the crop. Professor Davenport, when speaking of the members of this important family, says: "They not only work for nothing and board themselves, but they pay for the privilege." These plants are the only ones of any agricultural importance that can use the atmospheric nitrogen, and they can do it only with the aid of certain bacteria.

Figure 3 is typical of the alfalfa plant in blossom, and shows its peculiar habit of bearing the flowers all along the stem and not simply at the tips as the clover blossoms are borne. The seed is formed in spiral pods as shown in the illustration Fig. 4. Unlike red clover, alfalfa is a perennial and lives for an indefinite period. Near Lake Minnetonka, fields have been producing alfalfa for thirty years continuously.

Seeding.—The young alfalfa plant is rather delicate and a weak feeder consequently the seed bed must be carefully prepared, with a good supply of plant food readily available. The ground should be plowed rather deeply and the surface brought into a fine condition as in the sowing of clover or other small seeds. From ten to fifteen pounds should be sown per acre, preferably without a nurse crop, and as early as possible in the spring without danger of frost which may kill the young plants. As soon as the first blossoms appear or whenever the plant shows signs of losing thriftiness, it should be mowed as this stimulates stronger growth. It can usually be cut three times during the season, and after it has become well established, it will yield from three to five tons of cured hay per acre.

Soil.—Alfalfa seems to do best on sandy loam soils that have a good supply of plant food and are well drained though it has been known to have grown in a heavy clay soil. It will do well on any soil that will produce wheat or corn. The field designed for alfalfa should be selected with the view of leaving it for several years. The plant seems to reach its prime in four years and can as a rule be left in a field profitably for seven or eight years. No difficulty is experienced in getting alfalfa out of a field if it is plowed in mid-summer and kept well cultivated.

Fig. 3.—Alfalfa blossoms, reduced one-half.

Fig. 4.—Alfalfa Seed Pods

Harvesting.—Alfalfa for hay should be cut when one-third of the blossoms have appeared, because at this stage it makes the best quality of forage. It should be raked up into windrows when somewhat wilted, and never allowed to dry out before being raked, because then it does not cure so well and most of the leaves will be broken off in handling. It should be handled so as to preserve all the leaves since they are the most valuable part of the plant. In a dry season, it can sometimes be placed in the barn or stack the day after cutting, but it will usually be a better plan to a allow the hay to stand in cocks a few days.

Fig. 5.—Device for stacking Alfalfa hay.

Figure 5 shows the device used for stacking alfalfa on the farm of Mr. A. B. Lyman, Excelsior, Minn. The upright piece is made to turn freely, and the pulley at the base is so placed that as the load is drawn up, the rope pulls the arm around so that the hay is deposited in the center of the stack. Alfalfa seeds rather uncertainly; the second crop is usually better than the first for seed production. For seed it should be cut when the seed pods turn dark, and should be handled in the same way as is clover for seed. The yield is from two to four bushels per acre.

OBSERVATIONS FROM FARMERS.

Before venturing on the chemical study of the crop it was thought best to determine to what extent it was grown in the state and gain some information as to its possibilities. For this purpose letters were sent out early in the summer of 1902 to certain farmers and stockmen throughout the state, requesting them to give any information they could as to the extent to which alfalfa was grown in their vicinity and with what success. Incidentally inquiries were also made to obtain the methods of seeding and handling the crop and other general information. From letters received in reply to these inquiries, it was found that alfalfa has been grown with some success in Freeborn, Carver, Hennepin, Rice, Sherburne, Sibley, Lyon, Watonwan, Scott and Redwood counties. These counties are all situated in the southern and central part of the state. It is possible that successful attempts have been made in many other counties from which we have no reports. Few reports have been received from the northern part of the state. The following are letters received in answer to some of these inquiries:

New Prague, Scott Co.

"In this vicinity, alfalfa does best on black soil on high land. We sowed about 15 lbs. to the acre. We have about one acre which we feed to the hogs. For this purpose it is fine. They seem to like it better than red clover. We cut it from three to four times a year. It can stand a drouth and frost better than clover. I do not think it freezes out at all. I know of no one else around here who has raised it.

Yours truly,

ADOLPH SCHARF.

Excelsior, Hennepin Co.

"My attention was first called to alfalfa in 1881 when my father and I were about ten miles west of here in Lake Town. This was during the month of August, and a field

of alfalfa in full bloom attracted my attention. The German farmer, at whose place we stopped, was pleased when I spoke of the alfalfa and was greatly surprised to learn that we had none in our neighborhood. He told of its great feeding value for all stock and made, as the strongest point, that it was everlasting, while the red clover with him, often killed out the first year. This good report of this great forage crop did not appeal to my father as strongly as it would have later as we were more interested in grain than stock. However, the next spring, we purchased at Minneapolis, a few pounds of alfalfa seed with which we seeded a few rods of land in one end of a field that we seeded down to red clover. We were greatly surprised to find our everlasting clover all killed the next spring, while the red clover was not injured. We did not do anything more with alfalfa for some time.

"Ten years later, in 1890, I taught school about 15 miles from here and found the farmers all growing alfalfa. I noted its great feeding value and also that it *was everlasting*, as the farmers told me how long different fields had been seeded and no one had had it winter killed. Children in school often spoke of "everlasting clover." I reported at home the many advantages of alfalfa over red clover and the next spring we purchased again at Minneapolis ½ bushel alfalfa seed. We seeded about two acres alfalfa in barley and got a fine stand. The Germans often cut or pastured the first year after cutting the grain but we did not. Our alfalfa was about a foot high and went into winter thus. The next summer we cut three crops of hay and there was quite a fourth crop which we didn't cut or pasture. You can guess our surprise at finding the "everlasting (?) clover" all dead the next spring, also our surprise to find that the Germans had not lost a rod by winter killing. About this time there appeared an article in one of the Minneapolis papers stating that alfalfa was not a success in Minnesota except that it did well in Carver county. Our experience and observation and this article led me to form the opinion that common alfalfa was not hardy and that these Germans had a variety that was perfectly hardy. Since then, I have seen this proven a hundred times, have seen fields of common alfalfa and our hardy variety

seeded at the same time and separated only by a wire fence, and the alfalfa all kill out on one side of the fence and not on the other. This alfalfa was brought here some forty years ago and is said to have come from Norway. In 1894 we planted 1½ bushels of "everlasting" alfalfa on about seven or eight acres and have had no more trouble with winter killing. We have cut three crops annually except when we left the second crop for seed and have always pastured in the fall.

"I think a good stand can be secured with less seed when planted alone than any other way, yet have got good stands in grain. I consider 12 pounds per acre heavy seeding. The seed is much smaller than common alfalfa. Make a good seed bed and seed in April and harrow the seed in lightly. Cut two or three times the first year. It does well on all soils except meadow land and wet places. The alfalfa fields cut three good crops of hay each season; even during our dry years we cut three good crops when other hay hardly cut one.

"I think it cuts about four tons per acre. This variety of alfalfa cures much quicker than red clover. During a dry season it can be cut and put in the barn the next day. The past season, it needed to be left in shocks a few days. In shocks it turns rain well if put up before it is too dry.

"Some years, it seeds very heavy, while other years there is none all. I think it will average about three bushels per acre. Last year (1901) the seed crop was ruined by the extreme heat and this year (1902) by too much rain.

"We find there is a ready market for the hay. If a man feeds one load he will be sure to want more. One party drove ten miles to our place and purchased fifteen tons when he could have purchased common hay right at home.

"We now have seventy acres of "everlasting clover" and expect to seed about thirty acres in the spring."

Very truly yours,

A. B. LYMAN.

Grand Rapids, Itasca Co.

"Our test of alfalfa last year resulted in winter killing of

the greater part of the stand. We sowed Grimm's* alfalfa. Tests by Warren Pendergast gave similar results. So far we have not shown alfalfa to be hardy in this vicinity."

Yours truly,

H. H. CHAPMAN.
Supt. of N. E. Exp. Station.

Madelia, Watonwan Co.

"I have been raising alfalfa in a small way for about three years. I commenced with two acres and now have seventy seeded. It should be sown on well manured, well drained land. Prepare a good fine seed bed and sow as you would wheat or oats as soon in the spring as danger from heavy frosts is over. I sowed last spring with a common seeder. I mixed ¼ bushel of wheat with 15 pounds alfalfa and set the seeder to sow ½ bushel per acre. It was sown immediately after the spring rains commenced, and I have a very fine stand. I have just completed cutting the crop for hay. It should be mown at this time (August 1st) or earlier to give the alfalfa a better chance.

"I have secured two hay crops from my older fields amounting to about three tons per acre. I shall cut them once or twice more this season. Use any good corn land, sow from 15 to 20 lbs. of seed and do not allow live stock to pasture it the first season.

"I consider the hay to be about equal to red clover. As a soiling crop it will be superior to anything we have. I have given my experience to Mr. O. C. Gregg of the Farmers' Institute who will publish it in his Annual, No. 15." I remain

Yours truly,

JOHN BISBEE.

Belview, Redwood Co.

"In the year 1899, I seeded about 1½ acres of alfalfa with wheat to be used for hog pasture in the future. I used about 10 lbs. of alfalfa seed per acre and ½ bu. of wheat per acre. The wheat stooled remarkably well but when the alfalfa was about 6 inches high, I cut it with a mower. This

*This is the variety grown in the vicinity of Lake Minnetonka, and at the Exp. Station, is known as Minnesota No. 4.

checked the wheat to some extent. It still made a good crop of wheat by harvest. This patch was located in the bottom along the Minnesota River, slightly sloping towards the southwest and bounded on the southeast and southwest by tall timber. About ½ acre of the southwestern as well as the lowest portion was very sandy. The rest was very rich, black loam accustomed to clover. This upper portion seemed very promising the first fall but the sandy lot seemed rather weak. I left the stubble and did not pasture the first fall. In the winter the creek overflowed some of this sandy portion completely and smothered it. The next March, during nice weather, the alfalfa started to grow very nicely but during the alternate cold and warm spells about one-half of the plants seemed to rot off just below the crown, this made a poor stand. However, it made a fair hog pasture that year except the very sandy and poor soil, and I also used it for pasture in the spring and part of the summer of 1901, but as some more of the plants had damped off in the same way that spring, I decided to plough it up and seed to rape.

"The year 1900 I seeded about two acres just on the other side of the timber (southeast side) on quite, if not very sandy, very rich potato land, formerly clover. This time I seeded it alone. It grew very fast. I cut it down when 6 inches high and in addition to that I cut it three times for hay. The first time, it was only alfalfa hay, the next time it was more pigeon grass than alfalfa, and the third time, mostly alfalfa hay.

"During the very shifting weather of the next spring (1901) about one-half of the plants damped off in the same way as described. We therefore seeded about 12 lbs. more to the acre while the first seeding was only 10 lbs. That year, we took one good crop from the patch after which a long velvetish black bug took complete possession of the crop. It was kept eaten down all summer. By the way, this bug also attacked the soy beans and red clover to some extent and also some of the wild leguminous shrubs.

"As the blue grass which had remained in the land had stooled wonderfully during the summer, I thought it best to break it up, which I did last fall. I used the common Utah

grown seed. I found that the hay would cure nicely in cocks when raked rather green. To my judgment, alfalfa grows best on rich sandy loam in this neighborhood."

Yours truly,

G. E. ENESTVEDT.

Crookston, Polk Co.

"We have had considerable experience with alfalfa and there is no crop I have on the farm that has perplexed me more in the past than this. It will neither live nor die. It grows fairly well for one year, then a number of plants die out, but still there is enough growing to make a partial success.

"These struggling plants continue to grow for a long time. I have selected seed from some of these plants and have started to raise some alfalfa in a garden way. I have small garden plots of alfalfa that are doing very well. The Turkestan alfalfa is doing fairly well, but Minn. No. 4* is doing exceedingly well. I have no forage grass planted on the farm that has made such a growth as this one.

"Both these varieties came through the winter uninjured. I have now seed selected for more than one-half an acre which I shall sow this spring. I shall bear in mind to report to you of our success in case you so desire."

Yours truly,

T. A. HOVERSTAD,
Supt. N. W. Exp. Farm.

Faribault, Rice Co.

"I sowed an acre and a half of alfalfa four years ago which I mowed for hay three times a year and got a big crop every time. A year ago last spring, I sowed one-third of an acre which I mixed with Bromus grass. Last fall, I could hardly see any of the Bromus grass, but this year, the Bromus grass has improved greatly. I mowed this mixture four times and got about fifteen hundred pounds of hay every time. I cut it when the blossoms on the alfalfa would appear. This year, I sowed nine bushels of alfalfa on twen-

*This is the variety grown in the vicinity of Lake Minnetonka, sometimes called Grimm's alfalfa.

ty two acres which is a thick stand. I sowed the alfalfa with oats which I mowed for hay after it was headed out. About four weeks after, I mowed the young alfalfa again and left it on the ground. My soil is a heavy timber clay soil. I believe alfalfa is the most profitable feed we can raise for all kinds of stock.

Yours very truly,
NICHOLAS BECKER.

THE CHEMICAL DEVELOPMENT OF ALFALFA.

Although this work was not undertaken until a few days before the first crop was harvested, it was thought that data of value could be secured. Three samples of one square yard each were taken at weekly interval from a plot of a Western variety, and two samples at weekly intervals from a plot of a Turkestan variety. Both of these plots were in the field used by the Animal Husbandry Division; the Western variety was on range 4, plot 7; the Turkestan variety on range 4, plot 4. The results of the analyses, calculated on a basis of water free substance, are given in Table LXVI.

TABLE LXVI.

	Western			Turkestan	
	Cut June 3.	Cut June 10	Cut June 24	Cut June 3	Cut June 10
	Per Ct.	Per Ct.	Per Ct.	Per Ct.	Per Ct.
Total Nitrogen	3.28	2 85	2.06	3.03	2.67
Proteid Nitrogen	1.93	1.87	1.58	2.24	1.85
Per cent proteid nitrogen to total nitro'n	59 27	65.94	76.65	73.97	69.30
Crude proteid (Total nitrogen X6.25)	20.50	17.81	12.87	18.94	16.68
Ether Extract	2.50	2.48	2.13	2.28	2.26
Fiber	30.70	41.76	43,53	40.59	42.00
Nitrogen-free-extract	36.04	29.55	35.55	30.66	31.52
Ash	10.26	8.40	5.92	7.53	7.54
Lbs. Dry Matter per sq. yd.	265	295.8	362.7	260.4	257.2

The first crop from these two fields was harvested June 9th. It will be observed that on June 3rd, at which time, the first blossoms were appearing, there is the highest percentage of both total nitrogen and proteid nitrogen, and the lowest percentage of fiber for both varieties. This would indicate that the crop should be cut soon after the first

blossoms appear in order to secure, in the cured fodder, the largest percentage of protein, and the smallest percentage of fiber. By cutting as early as possible the growth is stimulated and more time is given for the second and third crops to reach maturity. Table LXVII gives the number of grams (28.3 grams in one ounce) of nutrients yielded by one square yard at the different stages.

TABLE LXVII.

	Western			Turkestan	
	Cut June 3	Cut June 10	Cut June 24	Cut June 3	Cut June 10
	Gms.	Gms.	Gms.	Gms.	Gms.
Total Nitrogen	8.69	8.42	7.47	7.89	6.87
Crude protein (nitrogen X6.25)	54.3	52.6	46.7	49.3	42.9
Ether Extract	6.62	7.34	7.73	5.94	5.81
Fiber	81.36	123.5	157.9	105.7	108.
Nitrogen free extract	95.5	87.4	128.9	79.8	81.
Ash	27.19	24.84	21.47	19.6	19.39

On June 30th, a square yard sample was taken of the second crop when it was about six inches high, and four samples were taken thereafter at weekly intervals, the last sample being taken July 29th, five days after the crop was harvested. The first blossoms appeared about July 22nd. These five samples were taken from the field of Turkestan alfalfa mentioned on page 162 and were prepared for analysis in the same way as those from the first crop. Table LXVIII gives the results of the analyses of these five samples.

TABLE LXVIII.

	Time of Cutting Sample				
	June 30	July 7	July 14	July 22	July 29
Total Nitrogen	5.00	4.20	3.62	2.92	2.65
Proteid Nitrogen	3.63	3.18	2.70	2.11	1.98
Per cent proteid to total nitrogen.	71.84	75.60	74.72	72.31	74.72
Crude protein (Total nitrogen X6.25)	31.25	26.25	22.62	18.25	16.56
Ether Extract	4.11	4.18	2.91	3.52	3.22
Fiber	19.32	24.37	30.08	32.41	34.20
Nitrogen-free extract	34.65	36.61	37.23	39.23	38.77
Ash	10.67	8.59	7.15	6.59	6.62

It will be observed that the total nitrogen and ether-extract decrease regularly as the crop grows and the fiber increases. The dry matter increases rapidly during the flowering period. The nitrogen is assimilated most rapidly in the early stages of growth and after the blossoms appear does not keep pace with the increase of dry matter. During this period, the proteids are being built up in the leaves and transferred to the stem. Table LXIX gives the total number of grams of nutrients yielded by one square yard at the different stages.

TABLE LXIX.

	Time of Cutting Sample				
	June 30	July 7	July 14	July 22	July 29
	Gms.	Gms.	Gms.	Gms.	Gms.
Total Nitrogen	2.05	2.84	5.83	8.60	8.85
Crude protein (nitrogen X6.25)	12.8	17.8	36.4	53.8	55.3
Ether extract	1.68	2.83	4.69	10.36	10.75
Fiber	7.92	16.50	48.49	102.3	114.2
Nitrogen-free-extract	14.20	24.78	60.00	123.8	129.5
Dry Matter	41.00	67.70	161.2	294.5	334.00

In general, the results of the work done on the second crop corroborate that on the first crop. The crop reaches the condition most suitable for cutting at the time when one-third of the blossoms have appeared. After this, a larger amount of much inferior hay is obtained. These results also agree with those obtained by the Kansas Agricultural Experiment Station. The chemical department of that station obtained the following results:

One-tenth in bloom.....18.5 per cent protein.
One-half in bloom.....17.2 per cent protein.
In full bloom.....14.4 per cent protein.

It is stated in the bulletin just referred to that "The late cutting of the first crop seems to injure the plant more than at any other time, and we have found it profitable to cut alfalfa the first time, as soon as one-tenth in bloom, even though the weather was bad and we knew that the crop would spoil in curing. The increased yield from succeeding cuttings over that cut late much more than makes up for

the loss of the first crop. Successful clover-growers the first time they try alfalfa often ruin the stand, so that it has to be plowed up, by waiting to cut until it reaches the stage at which clover is usually cut."*

The Utah Experiment Station for five years cut alfalfa at different stages of maturity and fed the crop in producing beef. The average production per year per acre was as follows:

	Hay.	Beef.
In first bloom	5.35 tons	706 lbs.
In full bloom	4.90 tons	562 lbs.
Half blooms fallen	4.55 tons	490 lbs.

In order to determine the proportion of dry matter in the alfalfa leaves to that in the stems, seven samples were taken at intervals of four days, and the leaves carefully separated from the stems. The leaves and stems were then dried and weighed. The results are given in the following table.

TABLE LXX.

	Dry Matter	
	Leaves	Stems
	Per Cent.	Per Cent.
June 3	42.78	57.22
June 7	38.62	61.38
June 11	40.39	59.61
June 16	36.08	63.92
June 21	36.32	63.68
June 25	34.68	65.32
June 30	36.08	63.92

An examination of the table shows that after the third sample, taken June 11th, which was two days after the crop was harvested, there is a noticeable decrease in the proportion of leaves to stems. Soon after the alfalfa plant begins to blossom, some of the leaves turn yellow and fall to the ground. We find the largest proportion of leaves to stems just before the blossoming period.

An analysis of the dry matter of the leaves, taken at the

* Kansas State Agricultural College, Bulletin No. 114.

time the first blossoms appear shows 23.06 per cent of crude protein (Nx6.25). Average wheat bran contains about 16 per cent crude protein. On June 3rd, six days before harvesting the crop, the leaves contained 63 per cent of the total nitrogen of the part of the plant above ground. On June 11th they contained 57 per cent, having lost 6 per cent because of the transfer of nitrogenous material to the stem which was going on quite rapidly at this stage. This shows the great value of the leaves and emphasises the importance of preventing any loss of this material in harvesting and feeding the crop. The results of the analysis of the dry matter of the leaves and stems, taken at the several periods, are given in table LXXI and reveal some interesting data.

TABLE NO. LXXI.

	TIME OF CUTTING SAMPLES.						
	June 3	June 7	June 11	June 16	June 21	June 25	June 30
LEAVES	Pr. Ct.	Pr. Ct.	Pt Ct.	Pt. Ct.	Pr. Ct	Pr. Ct.	Pr. Ct.
Dry Matter.	24.90	30.84	28.36	32.44	34.18	32.70	59.10
Total Nitrogen.....	4 36	3.66	3.73	3.12	2.74	2.74	2.77
Proteid Nitrogen.....	3.69	3.02	3.33	2.51	2.17	2.18	2 17
Per cent Proteid to Total Nitrogen	84.69	82.74	89.20	80.66	78.95	79.44	78.25
Crude Protein (Total Nitrogen X6.25)....	27.25	22.87	23.31	19.50	17.12	17.12	17.31
Ether Extract.....	2.56	4.48	4 48	3.80	6.12	5.45	4 56
Fiber.....	12.76	13.04	17.80	13.37	17.89	18.89	20.05
Ash.....	7.83	6.54	7.31	7.75	8.35	7.66	8.52
STEMS							
Dry Matter.....	.....	25.84	23.66	30.21	32.63	32.84	58.90
Total Nitrogen.....	1.95	1.76	1.88	1.59	1.65	1.60	1.46
Proteid Nitrogen.....	1.32	1.23	1.46	1.24	1.35	1.40	1.28
Per cent Proteid to Total Nitrogen.....	67.77	69.77	77.43	78.00	81.96	88.47	87.60
Crude Protein (Total Nitrogen X6.25)....	12.18	11.00	11.75	9.94	10.31	10.00	9.13
Ether Extract.....	1.19	.78	1.66	1.95	2.53	2.48	3.19
Fiber.....	50.76	48.13	46.69	48.21	48.16	48.12	55.15
Ash.....	6.79	5.56	5.62	5.36	6.00	4.98	4.61

It will be noticed that the percentage of dry matter increases quite regularly in both leaf and stem, being slightly higher at any given period in the leaf at every stage except

one. In the leaf both total and proteid nitrogen decreases as the plant ripens, the proteid nitrogen, however, decreases more rapidly. (The proteid nitrogen is that obtained by the use of Stutzer's method as given in the Methods of Official Agricultural Chemists. This proteid nitrogen has a greater food value than the nitrogenous material that exists in the non-proteid form.) In the stems, the total nitrogen decreases while the proteid nitrogen remains quite stationary which accounts for the increase in the percentage of proteid to total nitrogen. This seems to show that the nitrogen is taken from the soil in non-proteid or amide forms and is changed to proteid forms in the leaves and then transferred to the stems to be finally stored in the seed.

The ether extract increases in both leaves and stems but rather irregularly in the leaves. The fiber increases in the leaves but is almost stationary in the stem.

The percentage of ash or mineral matter remains almost stationary in the leaves but decreases in the stems. We find, as is to be expected, that the leaves contain the most ash, for it is in the leaf that the complex compounds found in the ripened plant are elaborated from simpler materials, and in this work the mineral elements take an important part. An examination of table LXVIII will show that the ash elements are taken up most rapidly during the early stages of growth. The results of the analysis of the ash of the leaves and stems are given in table LXXII.

TABLE NO. LXXII.

	IN 100 POUNDS OF ASH					
	Leaves Cut June 3	Leaves Cut June 16	Leaves Cut June 30	Stems Cut June 3	Stems Cut June 16	Stems Cut June 30
	lbs	lbs	lbs	lbs	lbs	lbs
Phosph't's(P_2O_5)	7.76	5.90	4.20	9.62	10.70	10.63
Potash (K_2O).....	17.17	14.61	11.60	26.68	31.16	27.54
Lime (CaO).....	24.90	24.39	32.41	14.10	13.42	15.98
Magnesia (MgO).	3.88	6.49	3.66	5.26	4 49	4.70

In the leaves, the ash elements are in almost every case found in the greatest abundance during the early stages. In the stems, there seems to be but little variation in the compo-

sition of the ash during this period, but the next table shows that there is a slight decrease in the percentage of the several ash elements owing to a decrease in the percentage of total ash. It must be noted that the blossoms appeared soon after June 3rd, the time the first sample was taken, so that this work represents only the last period of growth. The figures gven in the table following are calculated from the data of the table immediately preceding and the percentage of total ash.

TABLE NO. LXXIII.

	IN 100 POUNDS OF DRY MATTER					
	Leaves Cut June 3	Leaves Cut June 16	Leaves Cut June 30	Stems Cut June 3	Stems Cut June 16	Stems Cut June 30
	lbs	lbs	lbs	lbs	lbs	lbs
Phosph't's(P_2O_5)	.608	.457	.357	.653	.573	.49
Potash (K_2O).....	1.345	1.131	.988	1.812	1.67	1.268
Lime (CaO)	1.949	1.89	2.76	.957	.72	.735
Magnesia (MgO).	.303	.503	.312	.357	.24	.216

The most noticeable feature of the following table is the large amount of phosphates shown to be in the seed and the large amount of potash and lime in the cured hay.

TABLE NO. LXXIV.

	IN 100 POUNDS OF DRY MATTER				
	Alfalfa Cut June 30	Alfalfa Cut July 14	1st Crop Alfalfa Hay	Alfalfa Seed	Alfalfa Roots
	lbs	lbs	lbs	lbs	lbs
Total Ash.....	10.67	7.15	8.30	3.37	4.22
Phosphates (P_2O_5).....	1.10	.69	.61	1.72	.66
Potash (K_2O).....	2.54	1.65	2.99	1.11	.76
Lime (CaO).....	2.07	1.74	1.31	.05	.63
Magnesia (MgO).....	.46	.36	.32	.18	.34

An alfalfa field will yield on an average 8,000 pounds of cured hay per acre in one season. This cured hay will contain about 6,880 pounds of dry matter. The number of pounds of each of the four most important ash constituents removed from an acre by a season's crop of alfalfa hay, as compared with that removed by a crop of clover hay, is given in the following table:

TABLE NO. LXXV.

	POUNDS REMOVED IN AN ACRE CROP			
	Potash (K_2O)	Phosphates (P_2O_5)	Lime (CaO)	Magnesia (MgO)
Alfalfa Hay...	206	58	89	22
Clover Hay.....	66	28	76	17

Alfalfa draws most heavily on the lime and potash, resembling clover in this respect, but because of its heavier yield per season, a greater quantity of these ash constituents is removed. Most of the soil of Minnesota is well supplied with these ash constituents. If the alfalfa is fed on the farm and the manure well preserved and returned to the land, but little fertility is lost. If it happens that soils are poor in these constituents, fertilizers of lime in the form of land plaster and potash in the form of wood ashes can be profitably applied. The ash of alfalfa seed is rich in potash and phosphates; the samples analyzed contained 32.77 per cent potash and 44.29 per cent phosphate. It will be seen that when the seed is sold a considerable amount of this valuable ash material is removed from the farm.

With the aid of nitrogen gathering bacteria, alfalfa, like clover, can use the free nitrogen of the air, still it must not be inferred that a fair supply of nitrogen in the soil is unnecessary or that the application of nitrogenous fertilizers is always wasteful. Professor Bernard Dyer* of England has shown by careful experiments that "The use of moderate quantities of nitrate of soda has been decidedly remunerative." He found that in five years, an annual dressing of 1 cwt. of nitrate of soda per acre gave an increase of nearly three tons of green alfalfa fodder per acre per year, while an annual dressing of 2 cwt. per acre gave an increase of four and a half tons of fodder per acre per year. From this he calculated that there was an annual profit due to the nitrate of a little more than four dollars per acre in the first case and over six dollars per acre in the second case.

* Reprint from the 'Transactions of the Highland and Agricultural Society of Scotland,' Fifth Ser., Vol. XIV, 1902.

TABLE NO. LXXVI.

COMPOSITION OF DRY MATTER.

	Dry Mat'er	Crude Pro-tein	Ether Ex't	Fiber	Nitro-g'n free Ex't	Ash
	Pr. Ct	Pr. Ct.	Pr. Ct.	Pr. Ct.	Pr Ct	Pr. Ct.
Roots, Cut June 3	27.09	12.75	.78	35.13	46.09	5.25
Roots, Cut June 12	28.97	13.44	1.53	37.05	43.76	4.22
Blossoms, Cut June 12	18.58	19.37	3.28	19.55	52.25	5.55
Alfalfa, 5 months after Seeding	22.64	11.81	3.35	37.84	39.31	7.69
First Crop of Alfalfa Hay	89.71	15.00	3.06	33.27	40 37	8.30
Second Crop of Alfalfa Hay	89.38	17.62	2 08	34.33	40.00	5.97
Alfalfa Seed	93 40	36.94	10.61	13.55	35.29	3.61

The samples of roots and blossoms, as given in the table immediately preceding were taken from the Station plots. The five months old alfalfa was taken from the farm of Mr. Baird, Edina, Minn. The first and second crop alfalfa hay was taken from the farm of Mr. A. B. Lyman, Excelsior, Minn. The alfalfa seed was a sample of a Turkestan variety from the U. S. Department of Agriculture. The small amount of protein in the very young alfalfa is noticeable. The samples of hay from Mr. Lyman's farm are believed to be fairly representative of alfalfa hay produced in Minnesota.

Fig. 6.—Two-year-old Alfalfa plants.

THE FEEDING VALUE OF ALFALFA.

A comparison of the composition of the dry matter of alfalfa hay and clover hay is given in the following table:

TABLE LXXVII.

	Composition of the Dry Matter					
	No. of Samples Analyzed	Protein (Nx6.25)	Ether Extract	Fiber	Nitrogen-Free-Extract	Ash
Alfalfa hay.....	6	17.42	2.62	34.11	37.03	8.37
Red Clover hay...	4	12.97	3.43	26.82	49.95	7.83

The most striking feature shown in this table is the large amount of protein in the alfalfa hay. This substance is always the most valuable constituent of a feeding stuff. It is the substance which enters so largely into the composition of the flesh and the vital fluids of the body, and in a dairy animal, of the milk. Here then we have a source of protein which seems to be far superior to red clover which heretofore has held undisputed the title of being the best nitrogenous forage for Minnesota. With alfalfa as the source of protein and corn as the source of carbohydrates and fat, stockmen of Minnesota can produce cheaply an ideal ration for the production of both milk and meat.

Alfalfa makes a fairly satisfactory pasture for all farm animals but under the continued tramping the plants are often injured. It should not be pastured the first year and never so late in the fall as to force the plants to go through the winter with the crowns exposed, because in this condition they are apt to winter kill. In pasturing cattle and sheep on alfalfa there is some danger of bloat especially when the pasture is wet. Perhaps the better way to feed alfalfa is to mow it and allow it to wilt a short time before feeding. When fed in this way there is a larger yield of forage and no loss from bloat. Alfalfa has a laxative effect especially when fed green and for this reason it always gives best results when fed with some grain or dry fodder. Under these conditions it is also more digestible as is shown by the digestion trials reported in succeeding pages.

DIGESTIBILITY OF ALFALFA.

The value of a feeding stuff does not depend entirely upon the amounts of the several nutrients that enter into its composition, but upon the amounts of these nutrients that the animal can digest and use. In order to determine to what extent the nutrients of alfalfa are digested, several digestion trials were made. For these trials, two steers, weighing about 800 lbs. each, were courteously loaned by the Animal Husbandry Division and fed alfalfa hay for a period of about ten days before the trial proper began in order to accustom the animals to the ration. At the end of the preliminary period, the steers were put into specially constructed stalls as shown in Fig. 7.

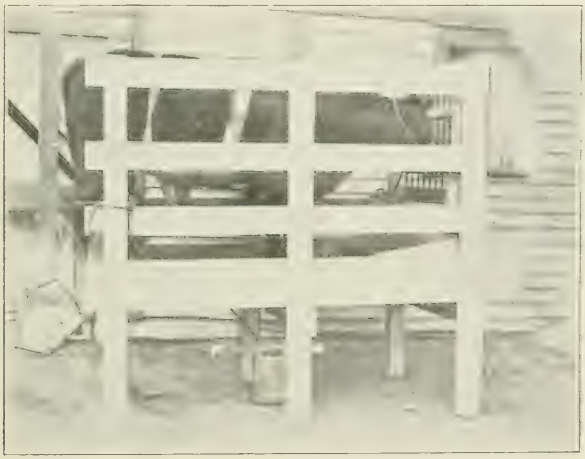


Fig. 7.—Steer in stall for digestion trial.

These stalls were designed by Professor Andrew Boss and built under his direction. The feeding was done under the supervision of Mr. George Craig, of the Animal Husbandry Division. The steers were weighed when put into the stalls and also when removed. The animals were left in the stalls for a period of four days and during that time all the food which they consumed was carefully weighed and samples taken for analysis. The excrements, both solid and liquid, were collected by the devices shown in the illustration.

These were weighed and sampled at the close of each day. The samples of the food and of the excrements were dried and analyzed. The methods of analysis used throughout this work were those adopted by the Association of Official Agricultural Chemists. The calories were determined by combustion in an Atwater-Blakeslee calorimeter. The heat of combustion of the daily samples of urine were determined in all cases except in the fifth trial and in the trial with hog millet. From the composition of the food thus determined and the total weight of food eaten by the animal during the four days, the total amounts of each of the food nutrients consumed were calculated. In the same way, the total amount of nutrients in the dung for the four days was determined. The difference in the amounts found in the dung and that found in the food eaten represents the amounts digested. This difference divided by the total amounts of nutrients consumed and the result multiplied by 100 gives the percentage digested. Five separate trials of four days each were made using in all, the same two steers.

In the first trial, the animals were fed first crop alfalfa hay of fair quality. This was cut in a feed cutter and the steers were fed all that they would eat up clean which amounted to almost 16 pounds of dry matter daily per steer. In the second trial, the daily ration consisted of 16 pounds alfalfa hay from the same lot as that used in the first experiment, and 5 pounds of corn meal. In the third trial, the daily ration consisted of about 42 pounds of green alfalfa, third cutting. In the fourth trial, the daily ration consisted of 16 pounds of alfalfa hay, 5 pounds barley meal and 15 pounds mangels. In the fifth trial, the daily ration was a duplicate of the ration of the second trial, viz.: alfalfa hay and corn meal, with the addition of about two tablespoonfuls of International Stock Food.* The object of this last trial was to determine the effect of a condimental food on the digestibility of a ration. A detailed account of the method of making these digestion trials and calculating the results is given in the Annual Report and also in a supplement to this bulletin. The results of these five trials are given in the following table:

* According to the Connecticut Experiment Station this material contains wheat feed, cayenne pepper, charcoal, salt and a bitter drug resembling gentian.

TABLE LXXVIII.—Coefficients of Digestibity of Alfalfa Hay.

	Dry Matter	Crude Protein	Ether Extr't	Crude Fiber	Nitrogen-free-extract	Ash	Digestible Calories
Alfalfa Hay							
Steer 181	68 60	76.59	57.84	58.23	75.48	54.89	67.15
Steer 184	63.09	74.17	53.92	56.91	68.25	47 92	61.67
Average	65.84	75.38	55.88	57.57	71.86	51.40	64.41
Alfalfa hay fed with corn meal							
Steer 181	71.80	84.02	61.46	64 60	73.64	66.98	70.93
Steer 184	70.16	83.25	60.19	61.98	73.24	62.70	89.26
Average	70.98	83.63	60.82	63.29	73 44	64.84	70.09
Alfalfa hay fed with corn meal and International Stock Food							
Steer 181	61.16	66 70	27.05	47.87	74.18	56.38	60.87
Steer 184	60.24	68.48	28.23	51.27	70.66	43.28	61.53
Average	60.70	67.59	27.64	49.57	72.42	49.83	61.20
Green Alfalfa							
Steer 181	60.62	73.46	37.75	42.17	72.21	40.34	62.46
Steer 184	60.63	74.65	39.08	42.66	71.26	39.66	63.17
Average	60.62	74.05	38 42	42.41	71.73	40.00	62.81
Alfalfa hay fed with barley and mangels							
Steer 181	63.63	74 90	53.29	48.41	73.36	63.22	60.21
Steer 184	63.51	77.56	56.46	49.64	70.68	61.64	60.81
Average	63.57	76.23	53.37	49.02	72.02	62.43	60.51

These trials show that alfalfa hay compares very favorably with that of our other principal forage crops. In considering the nutrients of a feeding stuff we must give the greatest prominence to the crude protein, the nitrogen free extract and the ether extract. Of these the crude protein is by far the most important because it is the nutrient usually lacking in a ration. The column headed Calories gives the percentage of the energy of the food that is digestible. This is determined by the heat given off by burning a certain weight of substance. The table shows that alfalfa hay is the most digestible when fed in a ration with corn meal, and next highest when fed with barley meal and mangels. When fed green, alfalfa shows a slightly lower digestibility than when fed as dry hay. This is probably due to the more laxative effect of the green food, which gives the digestive fluids less time to act on the food. A comparison of the two trials of the digestibility of alfalfa hay when fed with corn meal with the addition of a condimental food in one case, shows a remarkable difference in favor of the ration without the condimental food. The average digestibility of the protein in the two trials without the condimental food is 83.63 per cent, and with the condimental food is 67.59 per cent. With the other nutrients the difference is not as great but still in favor of the ration without the condimental food. The

condimental food seems to have much the same laxative effect as the green alfalfa, but to a greater extent.

Table LXXIX gives the percentage of digestible nutrients of Minnesota grown alfalfa hay as compared with that of some of our other common feeding stuffs.

TABLE LXXIX.

PERCENTAGE OF DIGESTIBLE NUTRIENTS IN DRY MATTER.

	Crude Protein	Ether Extract	Fiber	Nitrogen-free-Extract	Ash
Alfalfa Hay	13.13	1.46	19.64	26.61	4.30
Red Clover	7.52	1.89	14.53	32.13	2.28
*Timothy Hay	3.40	1.30	16.20	27.20	.....
*Corn Fodder	3.90	2.20	14.10	37.10	.....
*Barley	9.10	1.80	2.40	56.60	.....
*Corn Meal	9.00	2.80	1.00	66.40	.....
*Wheat Bran	12.50	3.60	3.60	38.50	.....

* Minnesota Experiment Station, Bulletin No. 36.

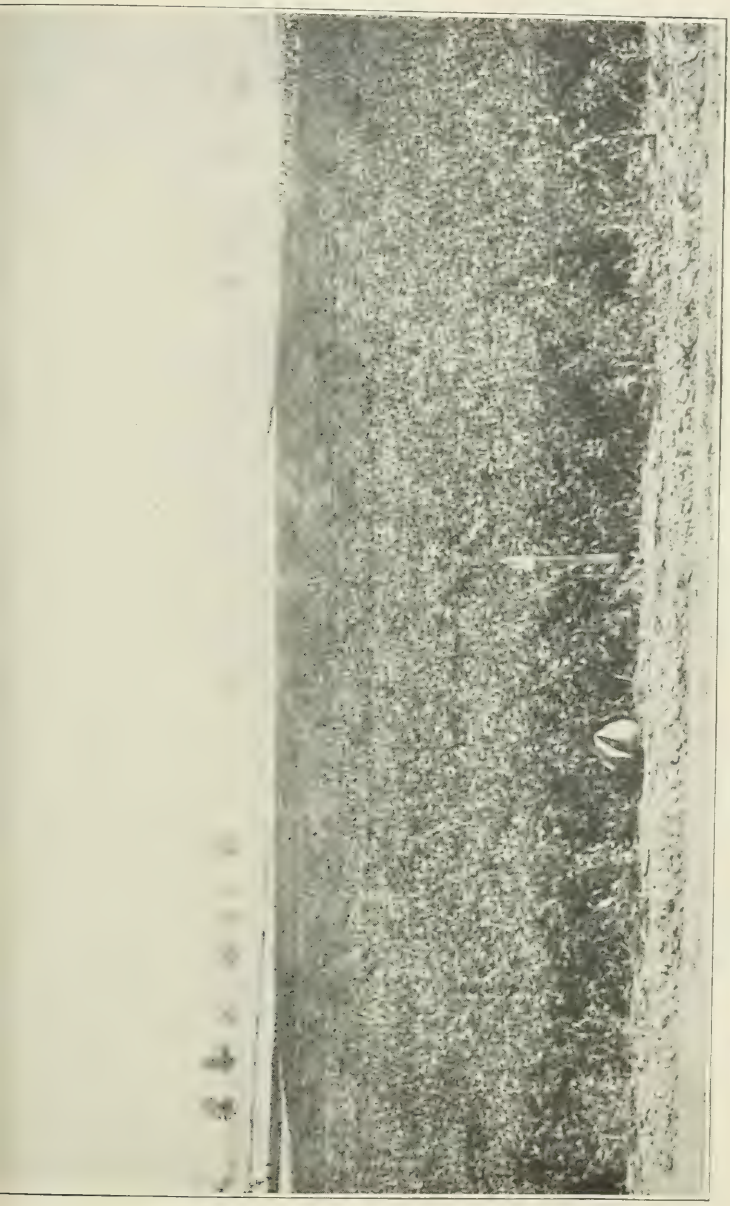


Fig. 8.—Alfalfa plat at Experiment Station; second crop, July 12. From field of Agricultural Division.

FERTILIZING VALUE OF ALFALFA.

Because alfalfa has the power of appropriating for its use the free nitrogen of the air, it has a high fertilizing value. A crop of alfalfa plowed under adds large stores of this most valuable plant food to the soil. The roots when decayed furnish to the soil large amounts of humus which improves it for crop production both chemically and physically. The Wyoming Experiment Station found that when alfalfa land was plowed and planted to wheat, it produced $8 to $12 more value in wheat per acre than the land that had grown potatoes and grain before. Alfalfa land gave $16 worth more of potatoes per acre than was obtained from land that had grown potatoes and grain before.*

In the digestion trial in which green alfalfa was fed, the solid and liquid excrement of the steers contained 94 per cent of the nitrogen consumed in the food. Of this amount nearly 75 per cent was contained in the liquid excrement. This shows the value of the manure, especially the liquid part and the importance of returning it to the land.

THE DIGESTIBILITY OF HOG MILLET.

(*Panicum miliaceum.*)

An examination of American Experiment Station literature fails to disclose any recorded results of work done to determine the feeding value of hog millet. This millet seems to be easily grown and produces seed fairly well in Minnesota, hence this work was undertaken.

For this trial, a hog weighing about 180 pounds was used. During the actual trlal the animal was fed 17 meals and the solid and liquid excrements were collected for a like period. A marker of charcoal was fed to the animal with the first meal and another after the last meal of the period. Only the feces which appeared between these markers was weighed and used for the analysis. Samples were taken at the close of every day, and these were carefully dried and a composite sample for analysis was made of all. The feeding of the animal and the collection of the excrements was done under the supervision of Mr. C. P. Taylor of the Animal

* Wyoming Experiment Station, Bulletin No. 44.

Husbandry Division. The millet was ground and was fed with water.

The following table gives the composition of the hog millet fed and of the composite sample of solid excrement.

TABLE NO. LXXX.

COMPOSITION OF DRY MATTER.

	Dry Mat'er	Crude Pro-tein	Ether Ex't	Fiber	Nitro-g'n free Ex't	Ash	Deter-mined Cal'r's
Hog Millet	87.87	13.40	4.47	19.22	58.71	4.20	4.597
Solid Excrement	.....	15.57	6.75	47.00	18.20	12.48	4.542

The calculation of the per cent digested of the several food nutrients is given in table LXXXI.

TABLE NO. LXXXI.

	Dry Mat'er	Ash	Crude Pro-teid	Ether Ex't	Fiber	Nitro-gen free Ex't	Calories
	Lbs	Lbs	Lbs	Lbs	Lbs	Lbs	
In Food	42.21	1.78	5.658	1.89	8.11	24.78	88.010
In Feces	11.50	1.44	1.79	.78	5.41	2.09	23.690
Digested	30.71	.34	3.87	1.11	2.71	22.69	64 320
Per cent Digested	72.75	19.17	68.36	58,86	33.36	91.56	73.07
Per Cent of Energy Available to Body	....	....	.....	....	.....	....	70.60

The animal voided in the urine .48 lbs. nitrogen, in feces .29 lbs. and consumed in food .905 lbs., having retained in the body .14 lbs. equivalent to .88 lbs. protein. The animal weighed at the beginning of the trial 181 lbs., at the close 191 lbs.

This trial shows hog millet to be about equal in digestibility to barley, wheat and shorts, but not as digestible as corn meal or oil meal.

The following table gives the digestible nutrients of hog millet along with that of some of our common feeding stuffs used for hogs.

TABLE LXXXII.

POUNDS OF DIGESTIBLE NUTRIENTS IN 100 LBS.					
	Dry Matter	Ether Extract	Crude Protein	Nitrogen Free Extract	Fiber
Hog Millet	63.9	2.6	9.2	53.8	6.4
Barley	70.6	1.8	9.1	56.6	2.4
Corn	80.1	3.1	9.2	67.4	1.1
Oats	65.5	3.9	9.2	49.4	1.6
Peas	80.2	.5	19.4	55.1	4.5
Rye	72.9	1.5	10.5	58.0	1.3
Wheat	73.0	1.5	11.0	57.3	1.3
Wheat Shorts	67.0	2.3	10.0	54.4	1.5
Red Dog Flour	78.0	2.0	13.5	60.1	1.2

A comparison of these figures shows that hog millet contains as much digestible nutrients as barley and oats and nearly as much as corn.

CONCLUSIONS.

A variety of alfalfa has been grown in Minnesota for thirty or forty years and has proved to be perfectly hardy wherever tried.

Alfalfa for hay should be cut when one-third of the blossoms have appeared because at this stage it will yield the largest amounts of the several nutrients in the most valuable forms.

Alfalfa produced in Minnesota contains more protein than red clover and has a greater feeding value than wheat bran.

Alfalfa hay contains large amounts of the most valuable fertilizing materials and when fed on the farm the fertility of the soil is increased.

Alfalfa hay is equal in digestibility to red clover. It is more digestible when fed with corn or barley meal than when fed alone.

Hog millet is equal in digestibility to barley, wheat and shorts, but is not as digestible as corn meal or oil meal.

Hog millet contains as much digestible nutrients as barley.

APPENDIX TO BULLETIN NO. 80.

J. A. HUMMEL, ASSISTANT CHEMIST.

In order to give in a more complete manner, the method of carrying on a digestion trial and of making the calculations, a more detailed account is given in these pages. As was stated in the preceding part of this bulletin, the animals were fed the ration to be studied for a preliminary period of about ten days in order to accustom them to the ration. They were then put into the stalls, usually at eight o'clock a.m. and the feces and urine collected, weighed and sampled each day for a period of exactly four days with the exception of the first trial which was extended over a period of five days. Samples of about eight or ten pounds of feces were taken at eight o'clock a.m. each day for the full period. From these samples the total dry matter was determined by drying in a water bath at 70 degrees C. A composite sample for analysis was made of these dried portions. Samples of the urine were also taken at eight o'clock daily. The specific gravity of the urine was determined and the determinations of total nitrogen and the heat of combustion were made immediately after sampling in order to prevent as far as possible decomposition of the urine.

In all of the analyses the methods adopted by the Association of Official Agricultural Chemists* were used.

The heats of combustion were in every case determined with a bomb calorimeter. The standard or unit of measurement of the heat of combustion is the Calorie, which is the energy in the form of heat required to raise the temperature of one pound of water 4 degrees F. The Calorie is equivalent to the work of lifting one ton 1.53 feet. The following description of the calorimeter and the method of using is taken from the U. S. Dept. of Agr., office of Experiment Stations, Bul. 101, pp. 11-12. "The bomb is made of fine steel and is lined with platinum. It consists of a cylinder to

* U. S. Department of Agriculturael, Division of Chemistry, Bulletin No. 46.

contain the substance to be burned and the oxygen for combustion, a cover to close the cylinder, and a collar to hold the cover tightly upon the cylinder. The material to be burned is compressed into a pellet in a press and is then placed in a small platinum capsule which is suspended by platinum wires from the cover of the bomb. A coil of fine iron wire, for igniting the substance electrically, is stretched between the two platinum wires which support the capsule and is made to rest upon the pellet within the capsule. The cover is then screwed tightly upon the cylinder of the bomb, and the oxygen is introduced through a valve in the cover until the pressure in the bomb is 20 atmospheres. The valve is then tightly closed and the bomb is placed in a Brittania metal receptacle containing a definite quantity of water the temperature of which is known. A metal stirrer, operated in this laboratory by a water motor, keeps the water in the receptacle in motion during the whole operation, and thus equalizes the temperature. When the bomb is immersed, a current of electricity is passed through the coil of wire resting upon the substance in the capsule, causing the wire to become incandescent and ignite the substance. Combustion takes place immediately, and the heat passes through the metal of the bomb and is absorbed by the water surrounding it. A calibrated Fuess thermometer is immersed in the water, and measures the rise in temperature of this known amount of water, from which the heat of combustion of the material is calculated, due allowance being made for the hydrothermal equivalent of the bomb and apparatus containing it (*i. e.*, for the amount of heat absorbed by these), for the heat introduced by the current of electricity in igniting the substance, the heat developed by oxidation of the metal fuse and small amount of nitrogen, etc. The hydrothermal equivalent of the bomb used in these investigations was determined by the combustion of samples of sucrose and of other substances of known purity."

The digestibility of a food is measured by the difference between the total nutrients of the food and of the feces. The materials in the feces do not consist entirely of undigested parts of the food but contain also products of metabolism, or the materials resulting from the breaking down of the

animal tissues. However, the material found in the feces represents approximately the amount that the body cannot use. Table LXXXIII which follows gives the composition of the materials used as food in these trials. Table LXXXIV gives the composition of the dry matter of the feces resulting. The amount of water in the feces is not given because it is necessary to consider only the dry matter.

TABLE LXXXIII.

No. of Sample		Water	Ash	Protein (Nx 6.25)	Ether Ex't	Fiber	Nitrogen Free-Ex't.	Calories
		Pr. Ct.	Pr. Ct.	Pr. Ct.	Pr. Ct.	Pr. Ct.	Pr. Ct.	Pr. Gr.
1	Alfalfa Hay	17.80	8.53	17.18	2.56	34.23	34.47	4.241
18	Alfalfa Hay	15.99	9.48	20.85	2.52	34 85	32.09	4.238
19	Corn Meal	12.83	1.55	10.87	4.44	3.35	79.79	3.861
30	Green Alfalfa	63.14	9.20	18.60	2.40	26.59	43.21	4.488
41	Alfalfa Hay	14 65	9.83	18.46	2.77	33.01	35.93	4.242
42	Barley	10.15	3.12	12.83	2.69	4.74	76.62	3.933
43	Mangels	91.13	12.40	15.79	2.25	10.15	59.41	4.062
54	Alfalfa Hay	14.65	8.14	15.41	2.12	35.00	39.33	4.453
55	Corn	11.47	1.71	13.86	4.24	3.35	76,84	4.010
58	Stock Food	10.00	12.05	13.12	4.34	6 00	54.50	3.553

TABLE LXXXIV.

Sample No.	FECES (Dry.)	Protein (Nx 6.25)	Ether Ex't.	Fiber	Nitrogen Free-Ex't.	Ash	Heat of Combustion per gm
		Pr. Ct.	Pr. Ct.	Pr. Ct.	Pr. Ct.	Pr. Ct.	Cal'r's
6	Experiment No. 1	12.50	3.52	45.70	25.87	12.41	4.243
7	" No. 1	12.28	3 14	42.48	30.82	11.28	4.364
8	" No. 2	11.98	3.42	39.80	32.18	12.62	4.379
9	" No. 2	12.06	2.98	41.20	32.34	11.42	4.437
20	" No. 3	13.76	3.41	40.85	31.00	10.98	4.368
21	" No. 4	13 51	3.34	41.59	29.89	11.67	4.372
31	" No. 5	12.53	3.78	39.24	30.49	13.96	4.279
32	" No. 6	11.98	3.69	38.72	31.53	14.08	4.198
44	" No. 7	14.58	3.46	42.69	27.43	11.84	4.499
45	" No. 8	13.46	3.26	41.49	29.58	12.21	4 510
56	" No 9	15.46	3.92	44.40	27.16	9.06	4.516
57	" No. 10	14.44	3.77	40.68	29.76	11.35	4.350

TABLE LXXXV.

Sample No.	URINE	Total amo't Voided	Specific Gravity	Nitrogen	Phosphoric Acid	Heat of Combustion per gm. of Urine	Calories pr. gm. of Nitrogen
		Gm.		Pr. Ct.	Pr. Ct.	Cal'r's	
2	Experiment No. 1	13,340	1.031	1.04	.108	.1182	11.3
3	" No. 1	10,410	1.031	1.22	.106	.1266	10.7
4	" No. 2	11,520	1.029	.98	.099	.0935	9.5
5	" No. 2	12,930	1.030	1.147	.077	.1205	10.5
10	" No. 3	8,029	1.032	1.165	.04	.0917	7.9
11	" No. 3	12,740	1.032	.95	.085	.0828	8.7
12	" No. 3	11,385	1.034	1.06	.089	.1077	10.1
13	" No. 3	13,548	1.038	1.05	.115	.1017	9.7
14	" No. 4	10,435	1.030	.89	.082	.1233	13.8
15	" No. 4	12,565	1.035	1.02	.032	.0848	8.3
16	" No. 4	12,430	1.034	1.11	.05	.0921	8.2
17	" No. 4	14,880	1.037	1.05	.056	.0972	9.3
22	" No. 5	12,490	1.035	1.24	.044	.1572	12.7
23	" No. 5	11,023	1.038	1.50	.051	.1855	12.4
24	" No. 5	11,020	1.035	1.44	.047	.1840	12.7
25	" No. 5	10,206	1.033	1.46	.104	.1526	10.5
26	" No. 6	13,110	1.033	1.33	.016	.1523	11.4
27	" No. 6	11,068	1.033	1.30	.018	.1728	13.2
28	" No. 6	14,200	1.030	1.26	.024	.1506	10.7
29	" No. 6	9,480	1.032	1.45		.1711	11.8
33	" No. 7	14,605	1.034	.96	.103	.1080	11.2
34	" No. 7	13,970	1.036	1.09	.116	.1317	12.3
35	" No. 8	14,061	1.031	.91	.045	.0842	9.2
36	" No. 8	18,410	1.031	.96	.064	.1075	11.1
37	" No. 7	15,285	1.034	1.02	.105	.1140	11.2
38	" No. 7	15,025	1.032	1.01	.088	.1077	10.7
39	" No. 8	12,985	1.031	.92	.053	.0992	10.8
40	" No. 8	16,150	1.031	1.01	.054	.1154	11.4
46	" No. 9	9,979	1.035	1.17			
47	" No. 9	13,290	1.037	1.16		Average	10.76
48	" No. 9	11,657	1.037	1.15			
50	" No. 9	9,301	1.036	1.22			
50	" No. 10	11,649	1.032	1.15			
51	" No. 10	12,655	1.032	1.08			
52	" No. 10	12,383	1.032	1.14			
53	" No. 11	11,567	1.032	1.23			

The urine voided in these trials was analyzed in order to determine the balance of income and outgo of nitrogen and the energy of the urine. The heat of combustion was determined by evaporating 10 cc. of urine on an S. & S. absorption block weighing about .7 gram. The heat of combustion per gram of the block was ascertained by trial. The phosphoric acid was determined gravimetrically from the residue left in the determination of the heat of combustion. Table LXXXV gives the analysis of the urine samples.

The total weight of each of the several nutrients in each food material and in the feces was calculated from the total weight of food and feces and the composition of these materials as given in tables LXXXIII and LXXXIV. As stated above, the difference between the total nutrients in the food consumed and the total nutrients in the feces represents the amounts that can be used by the body. We cannot assume the same for the difference of the total calories or energy of the food and feces because the oxidation or burning of the protein in the body does not yield the same amount of heat or energy as it does in the bomb calorimeter.

In the body, the protein is oxidized to urea and similar compounds, while in the bomb calorimeter, the oxidation goes further, and water, carbon dioxid, and free nitrogen are the final products. Hence this difference of energy in food and feces is too large to represent what is actually available to the body, so we subtract the total energy of the urine from this difference and call the result available energy.

Another method used to determine the calories or energy lost to the body in the organic matter of the urine is to multiply the number of grams of digestible protein by 1.25. This is the factor as worked out by Atwater and his associates.* This was the method used to determine the per cent of energy available to the body from alfalfa alone. In digestion experiments Nos. 9 and 10, this method was used for determining the per cent of available energy of total food as well because in this trial the heat of combustion was not determined.

In the trials where other foods were used with the alfalfa hay, the results that were actually obtained are the di-

* Conn. (Storr's) Station Report, 1899, p. 100.

gestion coefficients of the ration. By taking the digestion coefficients of these feeding stuffs other than alfalfa hay as determined by other experiments under similar conditions we can estimate the digestion coefficients of the alfalfa alone when fed in a ration. The digestion coefficients of corn used were taken from Jordan's "The Feeding of Animals" and are as follows: Dry matter, 89.4 per cent; crude protein, 67.9 per cent; ether extract (fat), 92.1 per cent; crude fiber, 58. per cent; nitrogen free-extract, 94.6 per cent. Likewise the digestion coefficients of barley meal used are: Dry matter, 86. per cent; crude protein, 70. per cent; ether extract, 89. per cent; crude fiber, 50. per cent; nitrogen-free-extract, 92. per cent. For the mangels: Dry matter, 78.5 per cent; crude protein, 74.7 per cent; ether extract, 50. per cent; crude fiber, 42.8 per cent; nitrogen-free-extract, 96. per cent.

In calculating the calories of the feces estimated as resulting from foods other than alfalfa, the following factors were used: Protein, 5.65; fat, 9.4; and carbohydrates, 4.15 Calories per gram.

The details of these digestion trials are given in the following tables:

DIGESTION EXPERIMENT NO. 1.

Kind of food.—Alfalfa hay.

Duration of trial.—Five days.

Steer No. 181.—Weight at beginning of experiment 795 pounds; at close, 805 pounds.

TABLE LXXXVI.

Sample No.		Dry Matter	Protein (Nx6 25)	Fat	Crude Fiber	Nitrogen-free ex't	Ash	Heat of Combustion
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Calories
1	In Alfalfa.....	79.70	13 69	2.04	27.29	29.89	6 79	153.320
6 and 7	In Feces.....	25.86	3.20	.86	11.40	7.33	3.06	50.370
	Digested.....	53.84	10.49	1. 8	15.89	22 56	3.73	102 950
	Pr. Ct. Digested...	68.60	76.59	57.84	58.23	75.48	54.89	67.15
	Pr. Ct. of Energy available to body							62 37

During this experiment, the animal eliminated 132.5 lbs. urine containing 1.5 lbs. nitrogen. The nitrogen balance was therefore as follows: Income in food 2.19 lbs.;

outgo in urine 1.5 lbs.; and in feces .41 lbs.; implying a gain of .28 lbs. nitrogen corresponding to 1.75 lbs. protein. The total heat of combustion of the urine as determined was 7330 calories.

DIGESTION EXPERIMENT No. 2.

Kind of food.—Alfalfa hay.

Duration of trial.—Five days.

Steer No. 184.—Weight at beginning of experiment 815 pounds, at close 845 pounds.

TABLE LXXXVII.

Sample No.		Dry Matter	Protein (Nx6.25)	Fat	Crude Fiber	Nitrogen free-ex't	Ash	Heat of Combustion
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Calories
1	In Alfalfa.....	79.70	13.69	2.04	27.29	29.89	6.79	153,320
8-9	In Feces.....	29.42	3.54	.94	11.76	9.49	3 54	58,780
	Digested.....	50.28	10 15	1.10	15.53	20.40	3.25	94,540
	Per cent Digested.	63.09	74.17	53.92	56.91	68.25	47.92	61.67
	Per cent of energy available to body							57.37

During this experiment, the animal eliminated 134.5 lbs. urine, containing 1.43 lbs. nitrogen. The nitrogen balance was therefore as follows: Income in food 2.19 lbs.; outgo in urine 1.43 lbs.; and in feces .56 lbs.; implying a gain of .20 lbs. nitrogen corresponding to 1.25 lbs. protein. The total heat of combustion of the urine as determined was 6585 calories.

DIGESTION EXPERIMENT No. 3.

Kind of food.—Alfalfa hay and corn meal.

Duration of trial.—Four days.

Steer No. 181.—Weight at beginning of experiment 820 lbs., at close 860 lbs.

TABLE LXXXVIII.

Sample No.	Food Consumed	Dry Matter	Protein (Nx6.25)	Fat	Crude Fiber	Nitrogen free-ex't	Ash	Heat of Combustion
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Calories
18	Alfalfa hay.....	62.63	13.05	1.58	21.82	20.10	6.07	120,390
19	Corn meal.....	17 43	1.89	.77	.58	13.91	.27	35,030
	Total.....	80.06	14.94	2.35	22.40	34.01	6.34	155,420
20	Feces.....	19.51	2.68	.67	7.97	6.05	2.14	38,650
	Estimated feces from food other than Alfalfa.....	1 85	.59	.06	.25	.75	.14	3,65
	Estimated feces from Alfalfa.....	17.56	2.09	.61	7.72	5.30	2.00	34,992
	Total amount digested.....	60.55	12.26	1.68	14.43	27.96	4.20	116,770
	Estimated digestible nutrients in Alfalfa.....	44.97	10.96	.97	14.10	14.80	4.07	85,390
	Per cent of total food digested.....	75 63	82.06	71.49	64.42	82.21	66.24	75 13
	Estimated per cent of Alfalfa digested.....	71.80	84 02	61.46	64.60	73.64	66.98	70.93
	Per cent of energy available to body.							
	In total food.....	.....	.....	.....	.....	.....	.....	72.31
	In alfalfa alone...	.....	.....	.....	.....	.....	.....	65.77*

During this experiment, the animal eliminated 100.7 lbs. urine containing 1.05 lbs. nitrogen. The nitrogen balance was therefore as follows: Income in food 2.34 lbs.; outgo in urine 1.05 lbs ; and in feces .43 lbs.; implying a gain of .86 lbs. nitrogen corresponding to 5.37 lbs. protein. The total heat of combustion of the urine as determined was 4392 calories.

* Calculated from digestible protein.

DIGESTION EXPERIMENT No. 4.

Kind of food.—Alfalfa hay and corn meal.

Duration of trial.—Four days.

Steer No. 184.—Weight at beginning of experiment 840 lbs., at close 875 lbs.

TABLE LXXXIX.

Sample No.	Food Consumed	Dry Matter	Protein (N x 6.25)	Fat	Crude Fiber	Nitrogen free ex't.	Ash	Heat of Combustion
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Calories
18	Alfalfa hay	62.63	13.05	1.58	21.82	20.10	6.07	120,390
19	Corn meal	17.43	1.89	.77	.58	13.91	.27	35 030
	Total	80.06	14 94	2.35	22.40	34.01	6.34	155,420
21	Feces	20.54	2.78	.69	8.54	6.13	2.40	40,730
	Estimated feces from food other than Alfalfa	1.85	.59	.06	.25	.75	.14	3,658
	Estimated feces from Alfalfa	18.69	2.19	.63	8.30	5.38	2.26	37.072
	Total amount digested	59.52	12.16	1.66	13.86	27.88	3.94	114.690
	Estimated digestible nutrients in Alfalfa	43.94	10.86	.95	13.52	14.72	3.81	83.318
	Per cent of total food digested	74.34	81.40	70.64	60.47	81.97	62.15	73 80
	Estimated per cent of Alfalfa digested	70.16	83 25	60.19	61.98	73.24	62.70	69.26
	Per cent of energy available to body.							
	In total food	.....	.....	.....	.....	.....	.....	70.61
	In alfalfa alone	.....	.....	.....	.....	.....	.....	64.11*

During this experiment, the animal eliminated 110.9 lbs. urine containing 1.14 lbs. nitrogen. The nitrogen balance was therefore as follows: Income in food 2.34 lbs.; outgo in urine 1.14 lbs.; and in feces .44 lbs.; implying a gain of .76 lbs. nitrogen corresponding to 4.75 lbs. protein. The total heat of combustion of the urine as determined was 4942 calories.

* Calculated from digestible protein.

DIGESTION EXPERIMENT No. 5.

Kind of Food.—Green alfalfa.

Duration of trial.—Four days.

Steer No. 181.—Weight at beginning of experiment 870 lbs., at close 860 lbs.

TABLE XC.

Sample No.		Dry Matter	Protein (N x 6.25)	Fat	Crude Fiber	Nitrogen free-ex't	Ash	Heat of Combustion
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Calories
30	In Alfalfa	63.04	11.72	1.51	16.76	27.24	5.80	128,330
31	In Feces	24.83	3.11	.94	9.74	7.57	3.46	48,180
	Digested	38.21	8.61	.57	7.02	19.67	2.34	80,150
	Per cent Digested.	60.62	73.46	37.75	42.17	72.21	40.34	62.46
	Per cent of Energy available to body.							56.54

During this experiment, the animal eliminated 98.7 lbs. urine containing 1.38 lbs. nitrogen. The nitrogen balance was therefore as follows: Income in food 1.87 lbs.; outgo in urine 1.38 lbs.; and in feces .50 lbs.; implying a loss of .01 lbs. nitrogen corresponding to .063 lbs. protein. The total heat of combustion of the urine as determined was 7597 calories.

DIGESTION EXPERIMENT No. 6.

Kind of food.—Green alfalfa.

Duration of trial.—Four days.

Steer No. 184.—Weight at beginning of experiment 850 lbs., at close 865 lbs.

TABLE XCI.

Sample No.		Dry Matter	Protein (N x 6 25)	Fat	Crude Fiber	Nitrogen free-ex't.	Ash	Heat of combustion
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Calories
30	In alfalfa	63.04	11.72	1.51	16.76	27.24	5.80	128,330
32	In feces	24.82	2.97	.92	9.61	7.83	3.50	47,260
	Digested	38.22	8.75	.59	7.15	19.41	2.30	81,070
	Per cent digested..	60.63	74.65	39.08	42.66	71.26	39.66	63,17
	Per cent of energy Available to body							56,80

During this experiment, the animal eliminated 105.5 lbs. urine containing 1.40 lbs. nitrogen. The nitrogen balance was therefore as follows: Income in food 1.87 lbs.; outgo in urine 1.40 lbs.; and in feces .48 lbs.; implying a loss of .01 lbs.; nitrogen corresponding to .063 lbs. protein. The total heat of combustion of the urine as determined was 7444 calories.

DIGESTION EXPERIMENT No. 7.

Kind of food.—Alfalfa hay, barley meal and mangels.

Duration of trial.—Four days.

Steer No. 181.—Weight at beginning of experiment 905 lbs., at close 905 lbs.

TABLE XCII.

Sample No.	Food Consumed	Dry Matter	Protein (N x 6.25)	Fat	Crude Fiber	Nitrogen free-ex't.	Ash	Heat of Combustion
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Calories
41	Alfalfa hay	55.05	10.16	1.52	18.17	19.78	5.41	105,210
42	Barley meal	17.97	2.31	.48	.85	13.77	.56	35,680
43	Mangels	5.32	.84	.12	.54	3.18	.66	9,840
	Total	78.34	13.31	2.12	19.56	36.73	6.63	150,730
44	Feces	23.67	3.45	.82	10.10	6.49	2.80	48,310
	Estimated feces from food other than alfalfa	3.65	.90	.11	.73	1.22	.81	6,451
	Estimated feces from alfalfa	20.02	2.55	.71	9.37	5.27	1.99	41,859
	Total amount digested	54.67	9.86	1.30	9.46	30.24	3.83	102,420
	Estimated digestible nutrients in alfalfa	35.03	7.61	.81	8.80	14.51	3.42	63,351
	Per cent of total food digested	69.80	74.10	61.32	48.37	82.33	57.77	67,95
	Estimated per cent of alfalfa digested	63.63	74.90	53.29	48.41	73.36	63.22	60,21
	Per cent of energy available to body.							
	In total food	.....	.....	.....	.....	.....	.....	63.46
	In alfalfa alone	.....	.....	.....	.....	.....	.....	56.11*

During this experiment, the animal eliminated 129.6 lbs. urine containing 1.31 lbs. nitrogen. The nitrogen balance was therefore as follows: Income in food 2.12 lbs.; outgo in

* Calculated from digestible protein.

urine 1.31 lbs.; and in feces .44 lbs.; implying a gain of .37 lbs. nitrogen corresponding to 2.31 lbs. protein. The total heat of combustion of the urine as determined was 6767 calories.

DIGESTION EXPERIMENT No. 8.

Kind of food.—Alfalfa hay, barley meal and mangels.

Duration of trial.—Four days.

Steer No. 184.—Weight at beginning of experiment 910 lbs. at close 910 lbs.

TABLE XCIII.

Sample No.	Food Consumed	Dry Matter	Protein (N×6.25)	Fat	Crude fiber	Nitrogen free-ex't	Ash	Heat of Combustion
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Calories
41	Alfalfa hay	53.34	9.85	1.47	17.60	19.17	5.24	104,320
42	Barley meal	17.97	2.31	.48	.85	13.77	.56	35,680
43	Mangels	5.32	.84	.12	.54	3.18	.66	9,840
	Total	78.63	13.00	2.07	18.99	36.12	6.46	149,840
45	Feces	23.11	3.11	.75	9.59	6.84	2.82	47,280
	Estimated feces from food other than alfalfa	3.65	.90	.11	.73	1.22	.81	6,451
	Estimated feces from alfalfa	19.46	2.21	.64	8.86	5.62	2.01	40,829
	Total amount digested	53.52	9.89	1.32	9.40	29.28	3.64	102,560
	Estimated digestible nutrients in alfalfa	33.88	7.64	.83	8.74	13.55	3.23	63,491
	Per cent of total food digested	69.84	76.07	63.77	49.50	81.06	56.34	68.45
	Estimated per cent of alfalfa digested	63.51	77.56	56.46	49.64	70.68	61.64	60.87
	Per cent of energy available to body.							
	In total food							64.24
	In alfalfa alone							56.71

During this experiment, the animal eliminated 135.5 lbs. urine containing 1.29 lbs. nitrogen. The nitrogen balance was therefore as follows: Income in food 2.07 lbs.; outgo in urine 1.29 lbs.; and in feces .50 lbs.; implying a gain of .28 lbs. nitrogen corresponding to 1.75 lbs. protein. The total heat of combustion of the urine as determined was 6302 calories.

* Calculated from digestible protein.

DIGESTION EXPERIMENT No. 9.

Kind of food.—Alfalfa hay, corn meal and International Stock Food.

Duration of trial.—Four days.

Steer No. 181.—Weight at beginning of experiment 925 lbs., at close 940 lbs.

TABLE XCIV.

Sample No.	Food Consumed	Dry Matter	Protein (Nx6.25)	Fat	Crude Fiber	Nitrogen Free-ex't.	Ash	Heat of Combustion
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Calories
54	Alfalfa hay	57.70	8.89	1.22	20.20	22.70	4.70	116,560
55	Corn meal	17.70	2.45	.75	.59	13.60	.30	36,380
	International Stock Food	.28	.04	.01	.02	.18	.03	494
	Total	75.68	11.38	1.98	20.71	36.48	5.03	153,434
56	Feces	24.29	3.75	.95	10.78	6.60	2.20	49,750
	Estimated feces from food other than alfalfa	1.88	.79	.06	.25	.73	.15	4,138
	Estimated feces from alfalfa	22.41	2.96	.89	10.53	5.86	2.05	45,612
	Total amount digested	51.39	7.63	1.03	9.93	29.88	2.83	103,684
	Estimated digestible nutrients in alfalfa	35.29	5.93	.33	9.67	16.84	2.65	70,948
	Per cent of total food digested	67.91	67.06	52.02	47.95	81.91	56.27	67.57
	Estimated per cent of alfalfa digested	61.16	66.70	27.05	47.87	74.18	56.38	60.87
	Per cent of energy available to body.							
	In total food	.....	.....	.....	.....	.....	.....	64.76*
	In alfalfa alone	.....	.....	.....	.....	.....	.....	57.99*

During this experiment, the animal eliminated 95.3 lbs. urine containing 1.12 lbs. nitrogen. The nitrogen balance was therefore as follows: Income in food 1.82 lbs.; outgo in urine 1.12 lbs., and in feces .60 lbs.; implying a gain of .10 lbs. nitrogen corresponding to .625 lbs. protein.

* Calculated from digestible protein.

DIGESTION EXPERIMENT No. 10.

Kind of food.—Alfalfa hay, corn meal and International Stock Food.

Duration of trial.—Four days.

Steer No. 184.—Weight at beginning of experiment 955 lbs., at close 950 lbs.

TABLE XCV.

Sample No.	Food Consumed	Dry Matter	Protein (Nx6.25)	Fat	Crude Fiber	Nitrogen Free-ex't.	Ash	Heat of Combustion
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	Calories
54	Alfalfa hay	58.50	9.01	1.24	20.48	23.01	4.76	118,170
55	Corn Meal	17.70	2.45	.75	.59	13.60	.30	36,380
	International Stock Food	.28	.04	.01	.02	.18	.03	494
	Total	76.48	11.50	2.00	21.09	36.79	5.09	155,044
57	Feces	25.14	3.63	.95	10.23	7.48	2.85	49,600
	Estimated feces from food other than alfalfa	1.88	.79	.06	.25	.73	.15	4,138
	Estimated feces from alfalfa	23.26	2.84	.89	9.98	6.75	2.70	45,462
	Total amount digested	51.34	7.87	1.05	10.86	29.31	2.24	105,444
	Estimated digestible nutrients in alfalfa	35.24	6.17	.35	10.50	16.26	2.06	72,708
	Per cent of total food digested	67.13	68.43	52.50	51.49	79.69	44.01	68.01
	Estimated per cent of alfalfa digested	60.24	68.48	28.23	51.27	70.66	43.28	61.53
	Per cent of energy available to body.							
	In total food	.....	.....	.....	.....	.....	.....	65.13*
	In alfalfa alone	.....	.....	.....	.....	.....	.....	58.57*

During this experiment, the animal eliminated 106.5 lbs. urine containing 1.23 lbs. nitrogen. The nitrogen balance was therefore as follows: Income in food 1.85 lbs.; outgo in urine 1.23 lbs.; and in feces .58 lbs.; implying a gain of .04 lbs. nitrogen corresponding to .25 lbs. protein.

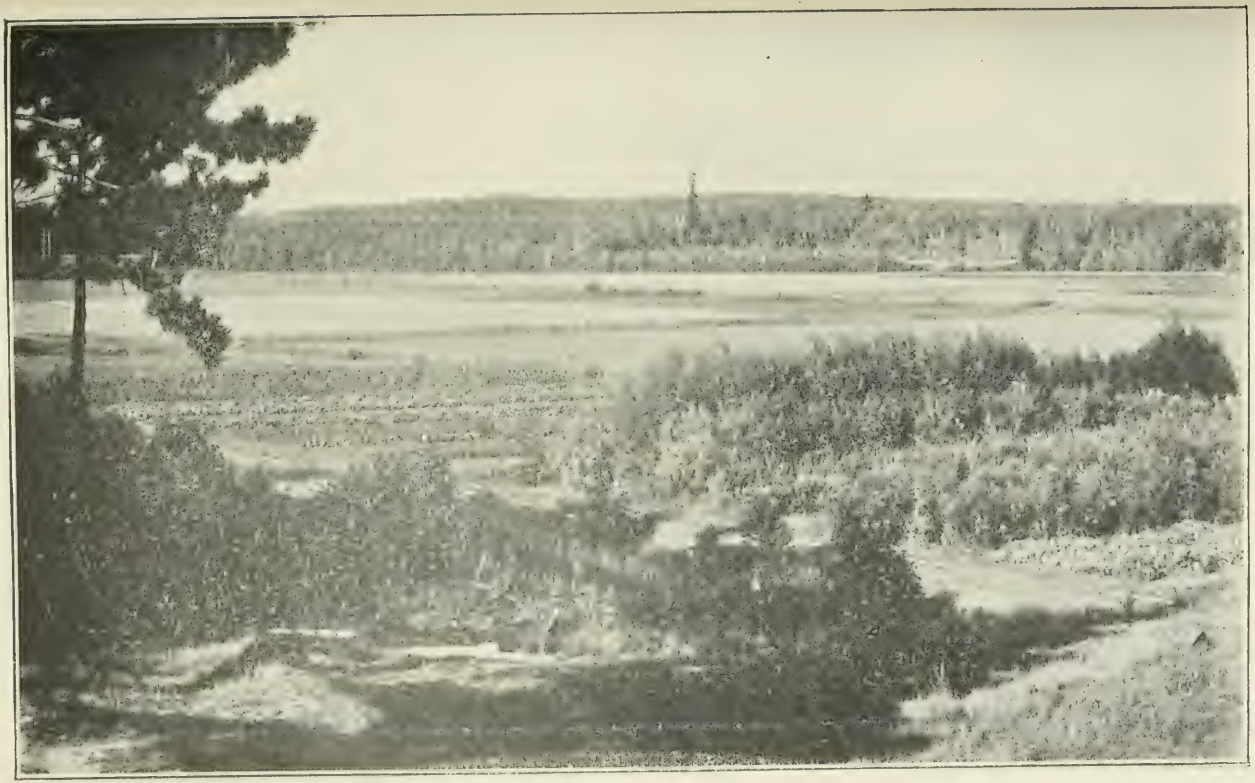
* Calculated from digestible protein.

TABLE XCVI.—Coefficients of Digestibility of Alfalfa.

	Dry Matter	Protein	Ether extract	Fiber	Nitrogen free-ex't.	Ash	Calories
Alfalfa hay, Steer 181	68.60	76.59	57.84	58.23	75.48	54.89	62.37
Alfalfa hay, Steer 184	63.09	74.17	53.92	56.91	68.25	47.92	57.37
Alfalfa hay fed with corn meal, Steer 181	71.80	84.02	61.46	64.60	73.64	66.98	65.77
Alfalfa hay fed with corn meal, Steer 184	70.16	83.25	60.19	61.98	73.24	62.70	64.11
Alfalfa hay fed with corn meal and International Stock Food, Steer 181	61.16	66.70	27.05	47.87	74.18	56.38	57.99
Alfalfa hay fed with corn meal and International Stock Food, Steer 184	60.24	68.48	28.23	51.27	70.66	43.28	58.57
Green alfalfa, Steer 181	60.62	73.46	37.75	42.17	72.21	40.34	56.54
Green alfalfa, Steer 184	60.63	74.65	39.08	42.66	71.26	39.66	56.80
Alfalfa hay fed with barley meal and mangels, Steer 181	63.63	74.90	53.29	48.41	73.36	63.22	56.11
Alfalfa hay fed with barley meal and mangels, Steer 184	63.51	77.56	56.46	49.64	70.68	61.64	56.71

TABLE XCVII.—Coefficients of Digestibility of Ration.

	Dry Matter	Crude protein	Ether extract	Crude Fiber	Nitrogen free-ex't.	Ash	Calories
Alfalfa hay and corn meal, Steer 181	75.63	82.06	71.49	64.42	82.21	66.24	72.31
Alfalfa hay and corn meal, Steer 184	74.34	81.40	70.64	60.47	81.97	62.15	70.61
Alfalfa hay, corn meal and International Stock Food, Steer 181	67.91	67.06	52.02	47.95	81.91	56.27	64.76
Alfalfa hay, corn meal and International Stock Food, Steer 184	67.13	68.43	52.50	51.49	79.69	44.01	65.13
Alfalfa hay, barley meal and mangels, Steer 181	69.80	73.61	61.32	48.37	82.33	57.77	63.46
Alfalfa hay, barley meal and mangels, Steer 184	69.84	75.63	63.77	49.50	81.06	56.34	64.24



Fields and Garden, Looking Northeast from House.

REVIEW OF THE WORK OF THE NORTHEAST EXPERIMENT FARM, SINCE ITS ORGANIZATION IN MAY, 1896.

EQUIPMENT AND IMPROVEMENTS.

During the seven years from April, 1896, to January, 1903, the experiment farm at Grand Rapids has largely perfected its equipment in buildings, fencing and machinery. The original purchase included a five room farm house, a horse barn, 30x40 feet, a chicken house 20x50, ice house, blacksmith shop and pig pen. Four rooms were added to the house to accommodate the farm help. Two large machine and storage sheds were added to the barn. The chicken house which was too large for warmth was made into a shed for sheep. The pig pen was moved and remodeled. An old root cellar, which was valueless on account of the rotting of the timber, was torn out and rebuilt with stone walls and roof of cedar, making a permanent structure 25x25 feet and accessable by wagon. Near this was built a small green-house hot-bed to be used in the spring for starting early cabbage and tomato plants. Over the well a stone well-house was constructed with cement floor for churning and separating milk. A tank was set in the roof of this structure, and connected by pipes with the barn, sheep pen, and house. In the fall of 1901, a new cow barn was built, 30x58 feet, with capacity for 40 tons of hay and 25 head of stock. This with a hay shed, which will hold nearly as much, provides abundant hay room. The water works were extended to the new barn and an additional shed for machinery constructed. The stock of farm implements now contains a full line of plows, cultivators, mower and rake, grain and corn binders, separator and power, wagons and small tools.

The fencing on the farm has been quadrupled. 160 acres was originally enclosed. The acreage now fenced includes 360 acres of the 455 belonging to the farm and has been sub-

divided into pastures, fields and lanes. There is now 2276 rods of fencing of which 770 rods is 5-wired sheep fence, the rest 3 and 2 wired for cattle.

Before the state had acquired it, the farm had been considerably developed, and devoted largely to raising potatoes. Much of the land that had been cleared was brush land, and was not difficult to get into shape. The acreage under the plow at that time approximated 60½ acres. At the present time there is 112¾ acres under cultivation, from which the stumps have all been removed, making a total of 52¼ acres cleared and stumped since '96. The stumps have been pulled but not removed on 5 acres, and on 3½ acres all brushing is completed. This with 5 acres in the buildings and yards, brings the total of improved land to 126¼ acres.

Open ditches were dug to drain the low places, connecting the west side of the farm with the river on the east, the length of which aggregates 355 rods. The barnyard, sheep and hog yards are fenced with woven wire.

OATS.

The commercial grain crop of this section is pre-eminently oats. Not only is this crop necessary for horse feed on the farm, but there is a constant demand for oats as long as logging operations continue. With a necessarily small acreage on a new farm devoted to grain, it would be unwise to raise wheat and buy oats for the team. Probably nine-tenths of the grain raised in the counties of Northeastern Minnesota will be oats for many years to come.

No grain varies so in quality as oats, due to the greater or less degree of fullness of the kernel. This is affected by the season, and by the climate. Oats from northern regions are heavier than those grown farther south, as a rule. Varieties of oats differ from one another very greatly, some being much heavier and larger yielders than others, regardless of the climate or season. It costs just as much to raise a poor oat as a good one, and the difference is clear profit to the farmer. The testing of varieties of oats has therefore been one of the chief aims of the work. During the seven years, forty-three kinds have been tried. To make the test as true as possible, the kinds tested are sown side by side in

equal plots on a level piece of ground. They are kept carefully separated in harvesting and threshing and the yields weighed and compared. One season is not enough, for different soils and different seasons affect varieties unequally. But if the same kinds are tested for five years, the average result should be trustworthy. Table XCVIII shows the re-

TABLE XCVIII.—Oats, Yields of Seven Varieties for Six Years.

Minnesota No.	NAME	1896	1897	1898	1899	1901	1902	Average Yield
6	Improved Ligowo.....	38.6	65.6	61.3	43.7	37.8	51.9	49.8
23	Lincoln.....	30.0	67.6	46.3	41.9	41.6	60.6	47.2
26	Early Gothland.....	21.0	63.4	45.0	40.7	45.3	59.7	45.8
4	Early Swedish.....	37.1	53.6	49.4	36.3	42.4	55.6	45.7
35	White Russian..... ..	35.7	61.7	41.9	40.9	46.6	46.4	45.5
29	Archangel.....	30.7	50.6	52.5	36.3	42.0	58.7	45.1
32	White Wonder.....	29.3	56.1	49.4	35.3	37 2	57.2	44.1

sults obtained from the seven kinds which have been sown every year since 1896. These are the survivors of twenty-one varieties with which the experiment was begun. From these, in 1899, the Improved Ligowo was selected for seed, as showing the heaviest yield and best quality. Since 1900 the field oats raised on the farm have been entirely of this variety, and 300 to 400 bushels of seed has been sold each year. The oat is becoming widely distributed throughout the region and reports received seem to indicate that it is an improvement in many cases over those previously grown. But, as the work of the station is continuous, efforts were at once made to secure a number of new kinds for further trial, in the hopes of finding something still better. Seed was received by the aid of the U. S. Dept. of Agriculture, from Sweden, Russia, Germany, Finland and Belgium, and some Canadian oats were added, which had stood well in the tests at the Government Experiment Farms. In all, twenty were secured, which with the nine best of the old kinds, are shown in Table XCIX.

NOTE.—The yield for 1900 was thrown out as it was impossible to save all the grain in harvesting, on account of continued wet weather.

TABLE XCIX.—Oats, Yields of Twenty-Nine Varieties for Two Years.

Minnesota No.	NAMES	1901	1902	Average
226	Swedish Marvel, (U. S. 617)	42.6	68.7	55.6
243	U. S. No. 5471	48.9	59.4	54.1
227	Indigene (U. S. 613)	41.1	66.5	53.8
26	Early Gothland	45.3	59.7	52.5
23	Lincoln	41.6	60.6	51.1
233	U. S. No. 2788	43 6	57.5	50.5
29	Archangel	42.0	58.7	50.4
194	Golden Sheaf	50.0	50.0	50.0
236	Strube, Germany	38.9	61.2	50.0
4	Early Swedish	42.4	55.6	49.0
252	Abundance	45.0	51.9	48.5
250	Early Blossom	39 1	55.9	47.5
256	Abyssinian	49.1	45.9	47.5
253	Golden Giant	54.1	40.6	47 4
255	Holstein Prolific	45.2	49.4	47.3
32	White Wonder	37.2	57 2	47.2
211	Silver White	44.5	49.7	47.1
35	White Russian	46.6	46.4	46.5
248	Ligowo, Agassiz	43.1	50.0	46.5
251	Wallis	39.4	53.4	46.4
237	Bull's	36.9	55.9	46.4
249	Ligowo, Nappan	47.5	42.8	45.2
6	Improved Ligowo	37.8	51.9	44 9
257	Rosedale	47.8	41.8	44.8
259	Banner	42.8	45.6	44.2
246	U. S. No. 5938	46.2	38 4	42.3
258	Lincoln, Agassiz	41.9	41.2	41.6
254	Thousand Dollar	34.1	48.7	41.4
247	Finnish Black (U. S. No. 6174)	36.9	36.9	36.9

It is evident that some of the imported varieties are of superior quality and yield and may supplant the present choice. Selection will not be made for at least another year and preferably two.

Oats are better adapted to new soil and unfavorable moisture conditions than wheat and will make a better showing when sown on breaking than will the other grains.

But it is better to plant new land to potatoes or corn fodder and follow with oats. Under such conditions larger crops are obtained. Old ground need not be plowed after potatoes or corn for oats, provided it can be worked up sufficiently with a harrow, for which purpose a disc harrow is best. If not in good condition, it is best to plow, and always in the fall if possible. An illustration of the difference in yield which may be obtained by different preparation of the soil, was given this season, when corn ground which had become compacted with the rains and grown up to some extent with timothy sods was laid off in plots and sown to oats after portions of it had been fall plowed, spring plowed, and not plowed at all. In this case it was not possible to work up the soil well enough without plowing it. The unplowed land gave 34 bushels per acre, the spring plowing 58 bushels, and the fall plowing 67.8 bushels per acre.

Oats will do well on sod, but the plowing should be done in August or early September, and care taken to lay a flat furrow, or in this climate the sod will not rot. On new land and newly cleared farms, much of the soil will be either too wet, or too raw and rooty to give best results. Under these conditions the average yield for the acreage sown may not be large. Poor seasons may also affect it. For the last seven years on the Experiment Farm, the average yield for the total acreage sown to oats was 35.2 bushels. In 1900 a severe drought, followed later by excessive rains which made it impossible to save the grain, reduced the average yield for the year to 18.7 bushels per acre. Without this year, the general average is 38.8 bushels. The variety tests have generally been placed upon soil not subject to dangers from excessive water, and these have given an average yield of 43.9 bushels, which may be considered fairly representative of the yield in good and poor seasons, on both old and new land. The largest crops have always been obtained the second year after breaking new land. In '96, land which had borne potatoes three years and was originally of the lighter, sandy character, gave 36.5 bushels. In '97, land broken in '95 and in corn the following year gave 47.3 bushels. In '98, similar land, broken a year later, yielded 52.8 bushels. In '99, a field broken in '97 and in corn in '98, gave 56.1

Oat Field.—View from House.

bushels while an old field of similar soil yielded 30.8 bushels per acre. It must not be supposed from this, that the fertility of the old fields can not be maintained—but it is true that under a careless system of cropping they will degenerate, as will any soil where sand is a conspicuous element. This same old field, which has been in cultivation since '93, gave a larger yield of oats in 1902 than at any previous time. But it has been in a three year rotation of oats, clover and corn fodder. In '96 the field yielded 36.5 bushels, in '99, 30.8 bushels, and in 1902 it gave 39.0 bushels per acre.

In 1900, much of the crop was a failure, the drought so affecting it in the early spring and summer that it produced a very thin stand and short straw. In this season there was a striking difference in the yield of different fields, ranging from 10 to 40 bushels per acre After analyzing the possible causes, it became evident that treatment of the soil, or other superficial causes, did not affect the result in this season, so much as the natural texture of the subsoil. Those fields which yielded well were in each case underlaid with

clay at from 6 inches to 2 feet deep. This held the moisture, and long straw was formed, with thick stools. The later rains matured a good crop of oats, averaging 38 bushels. Upon the other fields, the clay lay beyond the reach of the roots, and thin stools and short straw resulted, the yield being about 20 bushels per acre, much of which was lost from inability to shock it well enough to protect from constant rain. The season of 1901 was very favorable for growth and very thick and tall straw was formed. This was the year of the memorable hot spell. The hot weather shriveled the seeds as they were filling, and reduced a yield which promised seventy bushels, down to 25 bushels per acre. The rust aided some in producing this result, as this field was low lying. A much poorer field on higher ground, which ripened a week sooner, gave 39 bushels per acre.

The time to sow oats in this latitude is much discussed. It is safe to say that late sown oats on spring plowing will never do as well as early sown on fall plowing, in a dry season. In 1902 there was plenty of moisture, and the weather while the heads were filling was cold and cloudy, prolonging the ripening for over a week. Under these conditions oats sown on May 12th gave 50.6 bushels while those sown April 18th yielded but 39.8 bushels. In an ordinary season, with dry weather at harvest, the chances are all in favor of early sowing. The grain sown in 1901 on April 25 produced 37.2 bushels, while that sown May 9th gave but 22.8 bushels. The difference in time of ripening allowed the heat and rust to affect the later sown grain, while the early sown escaped.

To test the effect upon the yield of oats, by changing seed from one locality to another, an experiment is being carried on with the Experiment Station at St. Anthony Park near St. Paul. The same variety which is being grown here continuously is also exchanged every year between the two farms, and a third sample is grown three years at each farm in succession. The experiment has run for four years. So far the grain sent here from the other farm has out-yielded the home grown plot an average of 7.9 bushels, the yields being 33.2 bushels, and 41.1 bushels respectively for an average of three years.

Wheat.—The work which has been done with wheat has been chiefly to test the capacity of the soil and climate for its production, rather than to emphasize it as a crop for export. Wheat growing for the market should logically be confined to prairies or old and well developed communities, where nearly all the land can be cultivated by machinery. In this new and uncleared section wheat can only be raised profitably on a small scale to supply a local demand. On this account the same importance has not been attached to the testing of varieties as with oats, yet 21 kinds have been tried since '96. Of these the best eleven have been grown continuously for five years, and the yields are shown in Table C. The average yield of these varieties is shown for each year at the foot of the column. The general average of 17.4 bushels is as fair a figure as can be obtained for a representative yield of wheat in this vicinity.

TABLE C.—Wheat, Yields of Eleven Varieties for Five Years.

Minnesota No.	NAME	1898	1899	1900	1901	1902	Average Yield
169	Blue Stem	19.3	13.4	12.9	26.8	24.0	19.3
146	Bolton's Blue Stem	19.3	13.0	15.1	24.4	23.0	19.0
171	Ristings Fife	16.7	12.9	15.7	19.3	25.7	18.1
51	Haynes Blue Stem	23.0	11.7	12.1	20.4	22.7	18.0
167	Glyndon 761	15.7	11.7	15.2	20.2	24.7	17.5
165	Wellman's Fife	20.7	11.4	14.7	16.0	24.0	17.3
157	Glyndon 753	16.2	12.3	15.2	21.7	19.2	16.9
181	McKendry's Fife	17.3	12.2	14.2	18.3	22.0	16.8
163	Glyndon 811	14.7	10.7	16.2	20.2	22.3	16.8
66	Powers Fife	20.7	8.7	14.3	20.2	19.0	16.6
188	Preston	15.2	13.4	13.2	17.1	18.5	15.5
	Average of Varieties	18.1	11.9	14.4	20.4	22.3	17.4

If the wheat is grown on a small scale for home consumption as flour or chicken feed, the yield is more important than the grade. The Blue Stem wheats have so far averaged better than Fife. Three Blue Stem varieties tested, yielded an average of 1.2 bushels more than the best three Fife wheats, and 1.7 bushels better than the seven kinds of Fife in a five year test.

The well known principle that wheat should be sown as soon as the ground is fit in the spring applies as truly in this section as elsewhere. In 1900 wheat sown April 19 yielded 15.3 bushel and that sown May 7th gave 12.4 bushels while the plot sown May 15th only yielded 10 bushels. In 1901, the first plot was sown April 24, and yielded 22.7 bushels, or 6.7 bushels more than wheat sown nine days later, which gave 16 bushels. The difference is not always so marked and depends much on the season, but as there is nearly always some difference in favor of early sowing, it pays to be prompt.

Wheat should not be sown on ground subject to excess of moisture, as heavy rains at some periods are apt to reduce the yield proportionately more than would be the case with oats. In '96 drowning out brought the yield down to 8.9 bushels per acre, and in '97 to 14.9 bushels due to rain in July. In '99 late sowing (May 5th) and a wet season on rather low ground produced but 11.9 bushels per acre.

Wheat is more sensitive to the fertile condition of the soil than oats. The best yields obtained on the farm were in 1898 on ground that had been broken in '95, in corn one year, and in grain the year following. The stubble was fall plowed. By this time the land was thoroughly mellow and the crop yielded 28.6 bushels per acre. Another field that had borne two crops of potatoes and had then been manured for barley in '97, gave in '98, a wheat crop of 26.5 bushels. On a third field, the wheat yielded but 18.1 bushels. This field had received no manure nor been in grass since it was broken in '93 or '94, but had been cropped to potatoes. Its fertility was thus shown to be impaired.

To sum up, sow wheat on a small scale, which will enable the selection of a fertile, well drained piece, leaving the rougher, new or poorly drained ground for other crops. Sow Blue Stem for largest yields. Sow early, on fall plowing or on potato or corn ground that is sufficiently mellow to work up with the disc harrow and springtooth; never on spring plowing if avoidable.

In 1902 4 varieties of macaroni or goose wheat were tried. They averaged 15.4 bushels, as against 22.3 bushels for the ordinary wheats. Macaroni wheats are better adapted to

dry sections and will not be apt to yield as well here as Fife or Blue Stem.

Barley.—As barley cannot be profitably raised for export in this section, for much the same reasons as apply to wheat, its principle use is as a feed for hogs. The station has tested some eighteen varieties, of the two rowed and six rowed barleys for yield. The six rowed kinds prove to be the heaviest yielders. Manshury, one of the best, averages for seven years 24.9 bushels, while Champion of Vermont, the best two rowed barley, gives 21.6 bushels. Omitting the last three years, in which the tests were interfered with by unfavorable conditions, these averages are respectively 30.7 bushels and 25.4 bushels. For the four years 1896 to 1899 inclusive all the varieties tested averaged 24.6 bushels. Three crops were upon old ground, and the fourth was injured by water. The best yield was obtained in a field test in 1898, on new land broken in 1896 and planted in 1897 to squash. The ground was fall plowed and yielded 41 bushels per acre.

In 1900 barley sown about May 1st suffered from drought, yielding from 13 to 17 bushels, while that sown later, or on May 15th, received sufficient benefit from late rains to mature a crop of 27 bushels. In 1901, the plots sown on low ground were drowned out, yielding 12 bushels, and a field on higher and lighter soil gave 25 bushels per acre.

The field chosen in 1902 for the barley varieties gave interesting results. This field has been cropped since 1894, and had borne three crops of potatoes, two of grain and one of cornfodder. It was manured in 1898–'99 for the corn. In 1900 it was seeded down, but being a droughty field and in poor condition the dry weather burned out the grass. In the fall rye was sown, and in 1901 this was pastured off and corn planted which was also eaten off by sheep. The land was fall plowed and sown to barley. A dry spell after the grain was up, thinned out the straw on all the grain fields but later favorable weather matured a large crop of oats and wheat. But the barley on this field did not get moisture enough to form its straw and the crop averaged 8.4 bushels per acre. Clover seed sown with the grain flourished amazingly with the thin stand of grain and later rains, and furnished the means both to bring up the fertility and supply

the moisture holding humus, of which the soil on this field had been too far depleted.

Experiments on the best time to sow barley have been interfered with by other causes and have not given conclusive results. Danger from frost would not permit sowing much before May 1st in an ordinary season.

The season is sufficiently long to ripen all grains before frost. The following table gives an average of the actual dates of planting and harvesting grain, if the grain is cut when ripe, for seven years on the experiment farm.

Kind.	Sown.	Ripe.	Growing Period.
Barley	May 1st.	Aug. 1st.	93 days.
Oats	April 25th.	Aug. 12th.	109 days.
Wheat	April 25th.	Aug. 16th.	113 days.

On several occasions, the oats were sown first for convenience, and at other times they ripened proportionately later than wheat on account of being on lower ground. A slight correction can be made to bring the facts more in accord with a probable average, as follows:

Oats	April 25th.	Aug. 10th.	107 days.
Wheat	April 22nd.	Aug. 15th.	115 days.

Winter Wheat.—Two plots of winter wheat were sown in the fall of 1900, but owing to poor preparation of soil, the crop was injured, though the wheat lived over winter, and yielded but 7 and 10 bushels. In the fall of 1901 the seed saved was sown, together with fresh seed of the same two varieties, on Aug. 28th. The crop was not injured by the winter, and ripened July 31st. The seed from the defective plots of the preceding year yielded an average of 18.1 bushels per acre, while the new seed gave 22.9 bushels, or 4.8 bushels better. The wheat was of very good grade. In both seasons there was sufficient snow to furnish protection during the winter. This snow-fall, which the protection of the timber allows to settle evenly on the fields, is the cause of the success in growing winter wheat in this latitude, when it cannot be grown much farther south for winter killing. It is not safe to sow much later than Sept. 1st for the wheat will not have time to grow in the fall sufficiently to form hardy roots.

Speltz is attracting some attention as a grain for feeding

stock. The kernel resembles wheat but the husk adheres so closely that it cannot be separated in threshing and must be fed whole. It has no marked advantages as a feed over barley or oats, and unless the yield is greatly in excess of these, there is no reason for substituting it. So far the trials of speltz on the farm have not been encouraging. In '96 it yielded 11 bu. per acre on a low price. In 1902 the yield was correspondingly poor. When the conditions under which it is grown are more favorable, the station will be in better position to report upon speltz, but it is well to go slow on a novelty until it is proved to better than what already exists.

Winter Rye has been sown for six seasons and has never been injured by winter killing, not even in '97-8 when the clover was injured. It may therefore be considered a perfectly safe crop for this section. The rye sown has generally been either pastured or cut for hay. In 1902 that which was threshed gave from 25 to 30 bushels per acre. The field yielded 24.7 bu. while the average of five plots was 30 bu. The only things to be avoided in growing rye are standing water in the fall, and late sowing. Late rains injured the crop of '99 and '00, greatly reducing the yield. As rye grows vigorously in the poorest soil, it should logically be placed upon well drained and light land, both to escape the water and to make the best use of such soil. In this latitude rye may be sown, and has been sown for six years, as early as Aug. 15th, with no danger of its getting past the stooling period before winter. The plots sown in the fall of 1901 were at different dates, ten days apart to test the effect of late sowing on yield. The results were not uniform, the largest yield being from that sown Sept. 16th, after which there was a drop. But it was shown that rye could be sown at any time between these two dates, Aug. 15th–Sept. 15th, with success. One and one half bushels of seed were used. If pastured, either for cows or sheep, it should be done before the shoots appear as it then matures rapidly and becomes woody and unpalatable. This date is here about May 12th. By the 18th it is apt to be too late for pasturing. If cut for hay it will be ripe about June 10th and will give 1 to 1.5 tons per acre. It makes good hay but at this season the

weather is apt to be unfavorable for curing. The best uses are therefore as a grain, or for pasture. Needless to say, one cannot pasture rye in the fall and spring and then expect a grain crop of any size from the same piece. The further south the locality the later may rye be sown, and the earlier it will be ready for pasture or ripe.

Flax has been raised successfully, but prefers a heavy soil or new land. The chief objection to raising flax is the difficulty of marketing it in less than carload lots.

Buckwheat, if sown about June 1st ripens and produces a fair crop.

Beans if planted on a warm soil about May 20th, and well cultivated, will usually get ripe if early varieties are used.

Grasses and Clover.—Grass is the most important crop of this section, both from a financial standpoint and from that of proper farm management. Stock raising is largely dependent on it, and the utilization of wild land and processes of clearing are closely concerned with the uses that can be made of grass. Natural meadows are found along water courses and to some extent about lakes and sloughs. Occasionally they are of great extent and very valuable furnishing a source of hay which makes the raising and wintering of considerable stock possible almost at once. On the whole such supplies will tend rather to diminish than increase as the land is opened and drained and the surface water dries up.

The second source of supply is sought by pasturing, and seeding down for this purpose, upland which may or may not have been cleared and brushed. This brings into use the tame grasses. The success obtained in securing a catch, and a crop of grass, on such wild land, will depend upon the kind sown, the character of the soil, the amount of brush and sod, the preparation of the soil and the time of year sown. It is evident, that no general rules can be laid down nor can definite results be depended on. Merely scattering the seed will not always pay, though it requires the least expense. The nearest approach to success by this method is obtained on clay or heavy soils which have recently been heavily burned, killing most of the underbrush and leaving a coat of ashes on the surface. Thick underbrush

prevents grass from getting a start. Sometimes this may be destroyed by burning, but with the risk of doing damage both to soil and surrounding timber—of which risk the operator must be the judge. If the brush is thick and cannot be burned it must be mowed, preferably in June, or pastured off with sheep or goats, before a stand of grass can be secured.

On lighter, sandier soils, badly burned, and easily cleaned up of trash, grass may be sown broadcast. The stand will depend on the poverty of the soil, the amount of damage done in the burning, and the dryness of the season—and on such soils, will not generally be very successful.

Preparation of the soil increases the prospect of a good stand of grass, in proportion to its thoroughness. On rough stumpy ground, scratching with a V shaped spike tooth drag, or with a spring tooth, helps to tear up the surface and gives the grass a chance to get a foothold. Thorough pasturing by sheep, followed by such dragging produces still better results. But in general it is not well to expect too much with too little effort, and permanent grass land cannot be hoped for until the soil is broken and subdued.

Such seeding should be done in the spring, and as early as possible, preferably before the frost is all out, if the soil can be worked up on the surface. The kinds of grass most adapted to such seeding will be considered after a discussion of the results obtained on the farm in testing grasses.

The third and ultimate source of grass must be the raising of tame hay, on improved land, and consists in seeding down land that has been broken and has raised a few crops as potatoes, cornfodder or oats. By this means the soil is worked up, all brush and wild plants killed out, it is improved in surface drainage, is more level, and will be in condition to devote its entire growing energy to the grass. In return the grass roots fill the soil with a store of decaying fibers or humus.

The comparative value of different grasses can best be noted under these conditions, when they can reach their best productiveness. Soil and moisture conditions influence yields very greatly, and the character of the season as to distribution of rainfall sometimes reduces the crop one-half or doubles it.

In '96, plots were sown on soil of light sandy character that had been cropped for three years in potatoes. Table CI gives the yields of these plots for the three following seasons.

TABLE CI.—Yields of Grass and Clover Plots, Sown in 1896. Continued Three Years.

Plot	KIND	Date Sown	'97 Yield per Acre	'98 Yield per Acre	'99 Yield per Acre
			Tons		
1	Red Clover	May 11, '96	2.30	Plowed	
2	Alsike Clover	"	2.15	Plowed	
3	Timothy	"	.75	.61	.85
4	Red Top	"	1.00	.95	.93
5	Agropyrum Tenerum	May 1, '97		1.91	.70
6	Bromus Inermis	May 11, '96	1.08	1.18	.52
7	Orchard Grass	"	.03	.07	.27
8	Alfalfa	May 1, '97		.00	.00

In 1900, grass plots were sown on a soil of a lower, wetter character, underlaid with clay. The yields for two years appear in Table CII.

TABLE CII.—Yields of Grass and Clover Plots Sown in 1900, Continued Two Years.

Plot.	KIND	Date Sown	Yield per Acre, tons	2nd Crop	Total per Acre	Per cent of Other Grasses	Yield per Acre, tons	Per cent of Other Grasses	Corrected Yield
			'01			'01	'02	'02	
1	Timothy	Apr 23, '00	1.30			0	2.22	0	2.22
2	Red Top	"	1.20			2	2.12	0	2.12
3	Bromus Inermus	"	.85			10	1.40	5	1.33
4	Perennial Rye Grass	"	.65			80	1.00	80	.20
5	Orchard Grass	"	.25			70	1.18	95	.06
6	Mammoth Clover	"	2.45			0	2.85	10	2.56
7	Red Clover	"	1.90	.67	2.57	0	1.60	90	.16
8	Alsike Clover	"	2.45			0	2.83	10	2.54

In the spring of 1901, twelve plots were sown on a field that had been broken in '97 and cropped for three years in potatoes and other annual crops. The soil was silty loam, well mixed with humus and underlaid with clay at 12 to 18 inches. The yields of the varieties, and mixtures sown, for 1902, are given in Table CIII.

TABLE CIII.—Yields of Grasses, Clover and Mixtures, Sown in 1901.

Plot	KIND AND MIXTURE	Am't Sown pr Acre	Date Sown	Pr. Ct. in Crop	Yield Pr Acr '02	Second Crop	Total Yield '02
1	Red Clover	10	Apr 29, '01	100	3.26	.74	4.00
2	Alsike Clover	7	"	100	2.93		
3	Mammoth Clover	10	"	100	3.89		
4	Timothy	10	"	100	2.17		
5	Red Top	7	"	100	2.63		
6	Timothy Bromus	8 8	"	90 10	2.58		
7	Red Clover Timothy	6 9	"	75 25	3.13	.78	3.91
8	Red Clover Bromus Timothy	5 8 5	"	88 2 10	3.48	.76	4.24
9	Red Clover Timothy Red Top	5 5 4	"	80 15 5	3.72	.65	4.37
10	Alsike Clover Timothy	5 9	"	60 40	2.80		
11	Agropyrum	20	May 2, '01	100	2.35		
12	Agropyrum Red Clover	15 6	May 9, '01	10 90	3.50	.76	4.26

The plot tests as shown have been confined to the clovers red, mammoth and alsike, and the grasses, timothy, red top, bromus inermus, orchard grass, rye grass and agropyrum. Small garden tests have been made of other kinds, but none have given promise sufficient to warrant their use in preference to the above. Neither rye grass nor orchard grass have shown any valuable qualities. The yield of orchard grass both in tables CI and CII is seen to be nearly nothing and the plot is soon invaded by other grasses. Orchard grass appears to have some value as a lawn grass, as it catches and forms a sod, but it does not produce hay. Bromus inermis, or brome grass, which has been widely recommended for dry sections with good soils, has not been a success when sown alone, in the trials thus far made. It is not a complete failure, like orchard grass, but it does not thicken up to produce a large crop. It would be of more possible use on droughty soils than on low soils well supplied with moisture. For instance, in Table CI the yields on old land, sandy and rather dry, averaged for three years .93 tons against .74 tons for timothy, while in Table CII on lower and better

soil, timothy for two years gave 1.76 tons and bromus 1.15 tons, or about 64 per cent. This fairly represents the relative value of the two grasses on soils adapted to timothy. The comparison on sandy soils is probably in this case a little too much in favor of the bromus. Bromus when sown in a mixture, with timothy, will persist from year to year, but will not increase, to form a very large portion of the crop. While the seed remains expensive its usefulness is limited in this region, though it might be tried on a small scale for pasture mixtures.

Timothy through the cheapness of the seed, and good quality of hay for horses, is the most universally used of any grass. But no grass depends more on the moisture and fertility of the soil, for the production of a good crop. The ideal soil for timothy is quite moist, rich clay or loam. Impoverished, sandy or droughty soils produce very light crops. Witness Table CI on soil that had been in potatoes three years, where the timothy gave an average for three years of but .74 tons. In Table CII the average, on low soil well supplied with moisture, is 1.76 tons for two years, while in Table CIII, on new land, low, and five years from breaking, 2.17 tons were obtained in 1902. Timothy will do well on all land adapted to grass, but on land that is sandy, hilly and droughty, good results will not be obtained in all cases.

Red top has compared favorably with timothy in all of the tests, as the tables show. It flourishes best on moist land, and is a valuable addition to a mixture for meadow or pasture, with timothy. Agropyrum, or slender wheat grass has been tried twice, with the plots. It produces a slim stalk without much foliage and a wiry rather impalatable hay. The yield is fair compared with timothy and it will be tested further, especially on poor soil.

The results obtained with clover are the most striking, and important, of all the work done upon the Experiment Farm. Clover has the power of restoring fertility to worn out soils, by taking nitrogen from the air and storing it in its roots. If clover can be grown with certainty, it will make the difference between success and failure on much of the lighter land. The growing of clover on the farm has been a success from the first year. In seven years there has

been but one complete failure, caused by killing out in the snowless winter of '97–'98, when similar results were obtained all over the state. More important still, the clover seems to do well upon the lighter soils as well as the low and heavy fields. In table CI, 1897 with timothy yielding .74 tons, Red Clover yielded 2.3 tons per acre and gave in addition a second crop.

In 1899, 26.9 acres sown to clover gave 64 tons, or 2.42 tons per acre. The winter of 1899 and 1900, and the drought in spring of 1900 injured the clover so that there was very little in the first crop, but curiously enough, it came in after the first cutting of the meadow, and produced a very fair second crop.

In 1901 11.8 acres produced 19.5 tons of clover or 1.68 tons per acre. Eight acres of this was rough, rocky and a part of it swampy. In 1902, 22.1 acres were in clover, and the crop yielded 46.5 tons an average of 2.10 tons per acre. In 1900 the drought injured the catch on one field and it was plowed up, but other fields sown this year gave in 1901 from 1.4 to 3.3 tons per acre of clover. Thus out of six crops there has never been a failure to catch, and but one complete crop failure due to winter killing, and one partial one from drought. The four full crops averaged for all fields and all four seasons, 2.13 tons per acre for the first crop. The second crop has averaged about .75 tons, but has not always been cut.

In the comparison of red clover with mammoth and alsike clover, the second crop, and the subsequent yields must be considered. Red clover will, as shown, produce a heavy crop the year following the seeding, and in the fall of the same season will give a second cut of a ton or less. This practically exhausts it for hay, and there will not be a crop on the land the next year. There may be considerable clover, but it will be scattered and thin. The root of each red clover plant lives usually for but two seasons, and whatever clover appears the third year is the result of natural seeding. Not cutting the second crop but pasturing it, will as this crop generally bears the seed, result in more clover appearing in the meadow next year, but the main crop will even then be the other grass sown with the clover, or lacking this, wild grass

or weeds. Mammoth clover grows to a larger size than common red, ripens later, produces more hay, but does not give a second cutting, and one season usually exhausts it as with the red. Alsike clover is of finer growth than red, does not produce as much, though yielding well, and gives but one crop in a season. It thrives on wetter soil than red clover, and it is more persistent in nature. The comparative yields of these clovers under best conditions are shown with great fairness in table CIII. In table CII the red clover plot was injured by water. Table CI gives a fair comparison of red and alsike on poor soil. Ordinarily the test on such land would be more in favor of the red. The perennial nature of alsike when protected in winter by sufficient snow was well shown in 1901-1902. A field that in 1901 gave 1.6 tons alsike per acre, yielded in 1902, an average of 2.5 tons, with a more favorable season, nearly the whole crop being alsike. In the plot test in table CII alsike sown pure, gave a heavier yield in 1902 than the first season. In this test, mammoth clover, which had been cut late the preceding year, also came on and gave a large yield. But the red clover plot was overgrown with foreign grasses.

Alfalfa has been sown in three trials using hardy varieties but has never survived the winter. With clover so certain, it will not pay to experiment with alfalfa in the face of these results.

Taking up the subject of seeding brush-land, we must consider blue grass. This grass is nowhere in the state sown for hay, but in the southern portion is sown, or spreads, into pastures, and in time crowds out everything else. It produces pasture up to about June, but during July, Aug. and part of September there is practically no feed furnished by it except dry stalks. Its only possible use is in permanent pasture. The trials so far made, while not extensive enough for conclusive results, indicate that in this latitude the grass is of very little use even for pasture. It produces but scant feed and takes up the ground in place of other grasses. Its use should be restricted. The widest dependence must be placed on timothy, and for general seeding this may be mixed with red top using about one-fifth of the latter. It will probably pay to add clover on ordinary soils and especially

clays, and alsike on wet lands. Bromus would be worth trying in dry soils but it is difficult to cover and obtain a catch, on brush-land, and the seed is expensive. Other grasses have no proved value. Bearing in mind the biennial nature of red clover and the expense of the seed, the quantity sown with timothy for brush pasture should not be large. A good general rule would be six quarts timothy, one quart red clover, one quart red top per acre, which is 9 lbs. timothy and 2 lbs. clover, the weight of red top depending on its freedom from chaff.

For meadow on cultivated land, red clover and timothy should always be sown together. Alsike may be substituted on low ground. The clover will make almost the whole crop the first year, except when injured, when the timothy will take its place. The second season which is the third after sowing, timothy will make the bulk of the crop.

The subsequent treatment of the meadow determines the character and in a large part, the success of the farming in this region. It is natural for many reasons, to wish to have this land in meadow as long as possible. No labor is required but the haying, and more time can be spared on other work, as clearing. Again, when stumps have not yet been removed, plowing is difficult and slow. But against this is the fact that timothy will not continue to yield well on any soil, for a number of years, as the sod becomes tough and prevents the growth of new grass. On low soils the decrease will not be so rapid, but on light soils, the third year will sometimes see a diminution of the yield to a point where it would hardly pay to cut it. If meadow land is left in grass, the plowed land will be plowed every year for oats or potatoes, and its original stock of humus and fertility sadly drained. All the crops will suffer. The tendency will be to get everything into grass, and to work away from home as much as possible, instead of putting the time and work on the farm, and making it produce the living. If it is clearly recognized that sod should never be left more than two or, at most, three years, stumps will come out sooner, mowers and rakes will take the place of scythes, grass seed will always be sown with grain, and grain and cornfodder can have the benefit of fall plowed sod. The crops will be doubled, the fertility of

the land restored and retained, and a permanent home assured. Plow your sod. If the pressure of work is such that it cannot be done the second or third season let it be regarded as an error, to be remedied at the first opportunity, but never think of land seeded down as "taken care of" indefinitely.

On the Experiment Farm sod has never been allowed to lie over three years. On the lighter soil the second crop of clover has often been plowed under or the sod fall plowed the first year. The only field that has lain three years is a low rich piece of bottom land. The first year it yielded 2.9 tons of clover in the first crop, and a good 2nd crop. The next season that of 1900, the drought cut down the yield of timothy to about 1 ton per acre. In 1901 the field gave 1.91 tons timothy per acre and was then fall plowed for corn-fodder. On other fields the yield of timothy the second year has dropped to 1 ton or as low as .75 tons per acre, and if not plowed, would sink still lower. One of the poorest fields, rocky and partly swampy, which gave in '97 a good crop of clover, yielded in '98 .75 tons timothy. The following year this was pastured, and fall plowed. Grass and clover was sown with oats in '00, and in '01 the average yield for the whole field including bad spots was 1.47 tons clover per acre. It was pastured in the fall, and in '02 gave 1.02 tons per acre. It is safe to say that more grass was produced on this field than if it had been left in grass continually and the oat crop was raised in addition. Timothy will seldom exceed two tons per acre, while clover, with both crops will often go over four, but only when newly sown. A meadow fall plowed and sown to oats and clover will produce as much hay the second year as if left in grass for the two years, and will also give an oat crop, and the ground will then be richer for the clover, and the meadow renewed. Examples of clover yields have been given in general averages. The best fields have gone as high as three tons for the first, and one ton for second crop. In '98 a small field yielded 3.33 tons per acre. The second crop was fall plowed. In '02 a field of 10.3 acres gave 25.8 tons of cured clover, which would have been heavier if the hay could have been cured more rapidly. This field in the fall cut 10.3 tons of well cured second crop clover

from 7 acres, which grew to a height of 24 inches. Next year this field will yield largely timothy, and will not be left in grass longer than two more seasons. One of the oldest and longest cropped fields has been seeded down three times, the first in '96. The clover crop of '97 gave about 2 tons per acre with a good second crop. This field had been cropped to potatoes three years previously and was sandy. In '98 the timothy yielded but .75 tons and would have continued to yield poorly if left in grass. It was plowed for grain which in '99 gave 36 bushels per acre, and again seeded with clover and timothy. The drought in 1900 prevented a good crop on this light soil, by spoiling the clover stand. A portion was fall plowed for corn. The rest of field yielded in '01, .91 tons timothy, and was then fall plowed. In 1902 this field gave 39 bushels oats per acre, and an excellent stand of clover was secured for 1903. The crop of cornfodder raised on the sod in '01 went five tons of cured fodder per acre. Thus in spite of a failure of the stand in 1900, spoiling one of the two clover crops, the field has continued to produce good crops of grain, cornfodder and grass, solely through the rotation of the crops and the benefit the soil obtained from the decaying sod and the fertility added by the clover. No manure has been put upon the field since '95.

In seeding, the usual amounts used have been clover 3 qts., timothy 6 qts., or 6 lbs. and 9 lbs. respectively. As oats have been the chief grain crop, the grass seed has usually been sown with oats, though wheat or barley are in some cases better nurse crops. The seed may be broadcast and harrowed in, after the grain is sown. Both should be sown as early as possible. The average date of sowing grass seed on the farm for seven years, for all fields and seasons is April 26th, and it is planned to sow as early as the 18th or 20th if possible.

In haying, it is the aim to cut clover as nearly as possible at the period when about half the heads are brown. This date, for seven years has fallen between the 12th and the 18th of July, averaging about July 15th. Timothy, when pure and heavy, ripens three or four days later. The second crop of clover is fit to cut about Sept. 12th to 18th. Its weight depends not only upon the season and the soil,

but bears a direct relation to the time of cutting of the first crop. It starts to grow with great rapidity when the first crop is cut. The earlier this is done the heavier will be the 2nd crop. In 1902, a field of clover was cut July 16th, and yielded 2.5 tons, while the second crop gave 1.5 tons. On the same field, a plot was cut for the first crop, 9 days later, or July 25th, and gave 3.25 tons. This plot yielded .75 tons second crop. Roughly speaking, what is lost in weight by early cutting of first crop is made up in the second crop. This second crop of clover is of great value to the farm, as it can be turned to whatever use the needs of the farm demand.

Second Crop Clover for Pasture.

It is unexcelled as fall pasture, lasting till well along in October or after heavy frosts. On land lacking humus, or droughty it can be plowed under and will add immensely both to the fertility and drought resistance of the soil. In a season that threatens a wet fall, it is best to devote at least part of it to one of the latter uses, to avoid the danger of its spoiling from continued rains before it can be cured. In 1899

one field of 3.37 acres was cut in the fall and gave 1.15 tons per acre. On a second field of 15 acres, a portion was cut, a part pastured, and the rest plowed under. The year following, the land that had this clover plowed in yielded 35 bu. oats and 14.5 bu. wheat, with a good development of straw in spite of the dry spring, while on some other fields the straw was scarcely long enough to harvest and yield very low. A part of this difference at least, should be credited to the clover. Again, in 1902, two fields, or about seven acres were plowed under about Sept. 5th when the clover was one foot to 18 inches high. Another field of 2.5 acres pastured 75 sheep from Sept. 19th to Oct. 6th, furnishing in that time about two-thirds of their feed. A fourth field of 10.3 acres was divided, seven acres, already mentioned gave 10.3 tons of clover. The other 3.3 acres pastured 12 head of cattle from Sept. 15th till the second week in October. They ran in it after this date.

Clover will often grow with such luxuriance in the year it is seeded that it produces a large amount of foliage by fall. If stock are allowed to run on this during August and early September when the clover is getting its strength and storing up food in its roots for winter, with which to make the growth of the following spring, it cannot help but greatly damage if not utterly ruin the prospects of a crop. The leaves are the lungs and stomach of the plant and it cannot grow without them. But it is reasonable to suppose that after the middle of September, or later, the functions of the leaves have to a certain extent been performed, and it may be a matter of economy to pasture them off rather than let the frost harvest them. But rather than create the impression that this fall pasturing can do no harm, at any time, it would be better to take an absolute stand against it. Practice indicates that very late pasturing of very heavy seeding is not detrimental. The field which gave the heaviest yields in 1902, was pastured in the latter part of Sept. 1901, by cows, for three weeks, evidently with no evil results. Further experiments are being conducted along this line.

Clover, while so valuable a crop, both for its first and second crop, is not so easily cured in this latitude as could be wished. Promptness, and the cutting of the hay in cloudy

weather, to take advantage of all the heat and sun possible in curing, combined with tedding or pitching over in the swath, will usually save it in fair condition. The second crop should be cut in wet weather, rather than in dry, that it may be partially cured when the drying weather comes. Occasionally some has been lost, in a continued wet fall, but in 1902 it was saved in fair condition, after curing in winrow and cock for eleven days. In curing timothy, no difficulty need be experienced.

The work done with grass and clover on the experiment farm is by no means complete. In Table CIII were given the results of twelve plots, six of which are mixtures of different kinds of grasses and clovers for meadow. In 1902, twenty-two different plots were sown, of grasses, clovers and mixtures, including all of the varieties previously tested, and blue grass. These are so arranged that one-half of each plot can be cut for hay and the other half pastured by sheep. This will test the grasses and mixtures in two distinct ways, which will be a check on each other, and are sure to give useful results. The amount of seed to sow of clover and timothy, and the proportions of timothy and red clover seed best adapted for general seeding have been tested in a series of 22 plots sown in 1902. Results from these tests will be available next year.

Cornfodder.—It is no longer considered good agricultural practice, anywhere in the corn belt to grow corn with the intention of feeding the stalks to cattle after a crop of ears has been removed. The ears absorb most of the feeding value of the corn, and the remaining stalks are dry, woody and tasteless. But cornstalks were never more widely used than today, as a feed for stock. They are grown for this purpose alone, and sown thick, in rows, which prevents the formation of ears and allows the food material to remain distributed through the stalk. Here in northern Minnesota the reasons for growing corn for seed and fodder separately apply with still greater force than elsewhere. The kinds that will ripen seed are necessarily small in size, and the fodder that would be obtained from these stalks would hardly amount to a ton per acre of poor feed. But it requires much less time to mature corn for fodder alone and in consequence the same varieties

can be grown here for this purpose, as are grown in southern Minnesota, and nearly as large yields obtained. Cornfodder, grown in this way, becomes second only to hay in importance to the farmer in this section. In one way it is superior to hay. A bad season may materially reduce the hay crop, but with proper care and cultivation cornfodder can be

Cornfodder, Looking Southeast from House.

almost absolutely relied upon for a yield which will furnish ample food to take the place of hay. It thus gives to the dairyman and stock feeder a permanence and security which is of untold value to him. Cornfodder has been grown every year on the experiment farm and has never failed to yield well. Records were not kept of the yield of the fields for the first four years, but in 1900, when the hay crop was cut down by drought to less than a ton, a field of 3.1 acres gave 14.4 tons of cured fodder, or 4.67 tons per acre. In 1901, 39.2 tons were cut from 7.75 acres or 5.05 tons per acre, and in 1902, in a very cold and backward season, it still gave 3.9 tons per acre. The value of cornfodder was especially shown in 1900, when, in addition to the field mentioned, a second

field was sown as late as July 3rd, or after it became evident that the hay crop would be very short. This field of 3.2 acres gave 8. tons of cured fodder when cut Sept. 10th, or 2.5 tons per acre. The following winter, cornfodder was the chief reliance for the cattle, and it has always been extensively fed to the herd in place of the hay which can be sold for a good price. The yield per acre will depend somewhat on the kind of corn used for seed. If the small flint or very early dent kinds are planted for fodder, the yield may not be more than half what it would with larger dents. In '96 this was shown in a test of varieties, when the medium yellow dent known as Minnesota No. 13, gave 7.3 tons, and Squaw corn yielded 4 tons. This difference in yield is worth securing. Any dent that will mature in southern Minnesota or northern Iowa is suitable for fodder in this section. Very late and large kinds, as Giant Fodder, are not recommended, as they do not mature sufficiently during the growing season, and produce too coarse a stalk. In this connection, the time of planting, and method are quite important. The

Cornfodder, Lower Field.

corn, to make good fodder, should be ripe enough for the lower leaves to turn yellow. This result cannot be attained with the very late southern dents, and the fodder will be watery, sour and hard to cure. Dents from southern Minnesota will easily mature to this extent if planted at the right time. The date of planting on the farm has varied from May 31st to June 10th. The length of the season will depend on the frost in the fall. Should the corn freeze before it is cut, it is greatly damaged, and its flavor and feeding value reduced one-half. This freeze in seven years, has never come before Sept 7th, and the average date has been Sept. 14th. It is not safe then to delay starting to cut much after Sept. 5th. The earlier the corn is planted the sooner it will reach the desired state of maturity, and the more time there will be to take care of it before frost. While June 10th is not too late, it can be profitably sown as early as May 25th. If emergencies arise demanding the planting of late corn, as occurred in 1900, a crop may be secured as late as July 1st. It stands to reason that in planting at this date, better matured corn, and possibly just as much of it, can be raised from the seed of earlier flints or dents.

The method of planting has much to do with the size and quality of the crop. Planting in hills for fodder should be absolutely abandoned. The stalks are large and tough and yield low. Broadcast planting is often adopted, on the ground that it does away with cultivation and saves work. But the increased labor of cutting must be considered, and the results from broadcasting are very unsatisfactory. Weeds grow unless the stand is thick, and when it is, so many stalks are produced, that very often the moisture gives out before the crop is more than well started, and short sickly stalks result, difficult to handle, and with a total yield not equalling that obtained by planting in drills and cultivating. In proof of these facts, the plot planted in 1902, in hills, gave 2.4 tons, that sown broadcast produced 3.7 tons, while the drilled and cultivated plot yielded 5.4 tons per acre, or nearly one-third more than broadcast. Cultivation kills the weeds and prevents evaporation, so that all the moisture and fertility in the soil go to developing the crop. On a weedy piece this is especially important. In 1900, the plot sown broadcast,

gave 4.7 tons, nearly one half of which was weeds, while on the cultivated plot 5.25 tons of clean fodder was cut. If it is not possible or convenient to plant so as to admit of cultivation, one must not blame the corn, or the soil, for poor results. Three and one-half feet is far enough apart for cultivation and proper development. The seed may be sown with a grain drill if one is available by plugging most of the tubes, or with a common garden seed drill. It should be sown so that the kernels are not more than an inch apart in the row. This will take a little over a bushel of seed per acre. This close or thick planting insures small stalks, which the cattle will eat clean, and thus makes the whole crop available. The wider apart the stalks are in the row, the coarser they are, and the greater the waste in feeding.

Cornfodder will grow upon new land, and may even be sown in the furrow, in breaking, though it will not give its best results under such conditions. Still, if the soil is thoroughly worked down and does not dry out too much the yield will be fair. The yields are greatly increased by manure, which may be freshly applied in any quantity without injury. On worn soils the effect is striking. A sandy piece which had been cropped since '94 without manure, produced in 1901, a crop of 3.7 tons, while on the same piece in that year an application of 10 tons per acre of manure gave a crop of 6.84 tons, or an increase of 85 per cent. This same plot was again manured, and in 1902 yielded 5.44 tons while that not fertilized gave 2.65 tons, a difference of 105 per cent. The falling off in total yield for the plots for the preceding year was due to the season, which was one of the most cold and backward ever experienced. Cornfodder will also do well on sod land, but it should be fall plowed. In 1898 the crop was planted on spring plowed sod, and while it gave a good yield, the crop was not over half what it ought to have been, though exact figures were not obtained. The sod was not decayed and the corn suffered from lack of moisture. In 1901 this same field was planted to cornfodder on sod plowed the preceding fall. The yield was 5.05 tons per acre, due largely to the effect of the rotting sod. The field had been cropped without manure since '95, and its fertility maintained by the rotation

of grain crops, with grass in short periods. Where possible cornfodder has been planted on new land broken the previous summer, and worked down in the spring. The crops of '96, '97 and 1900 were raised on such land and gave large yields, while the cultivation of the crop left the soil in excellent condition for grain. The corn binder which is in universal use in other sections, can seldom be afforded on new and stumpy farms. Cutting by hand is facilitated by the planting in rows. The shock should not be large, though late in the fall, if the labor can be afforded, the small shocks may with profit be thrown together into larger ones for protection. In this section it is not possible to stack cornfodder, as it will always spoil in the stack. It should be fed from the shock. Cutting pays with coarse stalks, but where power and a cutter are not available it is a simple matter to grow them fine by close planting. The feeding value of cornfodder is equal to that of timothy hay, with the advantage of being succulent. It will not take the place of clover or of bran for milk cows, nor will timothy. But it will winter stock over in very fair condition.

Sorghum or sugarcane is occasionally tried in place of cornfodder. The experiment farm has demonstrated that this is a great mistake. Sorghum will never give the yield in this section that cornfodder will. In 1900, a season particularly favorable to sorghum by reason of dry, hot weather in the spring and summer, the yield was 3.8 tons as against 5.1 to 6.4 tons for cornfodder. In 1902, a cold, moderately wet year, sorghum gave practically no crop—cutting 1.25 tons, partly weeds, against 5 tons for corn. Sorghum is a plant for dry, hot climates, and the seed is much slower than corn to germinate, which cuts down the growing season and increases the danger of weeds choking out the crop. It should never be substituted for corn. The same is true of such crops as Kaffir and Jerusalem corn or Dhoura maize, Teosinte and others, all southern forage plants, the results from which on the experiment farm have been even less encouraging than with sorghum.

Millet is a heavy feeder and does best on bottom land. It is apt to be light on sandy soil. It is a useful crop when there is not enough meadow seeded down to produce hay

sufficient for the stock; though if cornfodder be used, there is not much necessity for millet. It is usually sown as a catch crop. In '99, after potatoes planted that spring had been drowned out, and failed to come up, millet was sown July 1st and produced over a ton per acre. Again in 1900, a field of 4 acres sown the preceding spring to grass, was burned out on a south exposure by the drought. This field was plowed and sown to millet on June 27th, and gave 1.25 tons per acre. German millet is about two weeks later in ripening than the common millet, and requires nearly the full season to ripen. It makes a difference, therefore, which variety is sown if late seeding is necessary. The late crop of 1900 was common millet, and was well matured for hay. That of '99 was German millet, and when cut, but few heads had appeared. The yield was about the same in either case but the more mature fodder was of a better quality for feeding. On the farm, the millet plots have been sown about June 1st. From that date till the 10th is the best period to sow the crop. If sown earlier, the seed will take so long to sprout, and the small plants develope so slowly that the weeds will generally smother the crop if they are present. In '97 millet was sown May 17th, and the weeds choked out the millet. In any case, the ground should be freshly dragged before sowing. Once well started, millet easily overcomes weeds. While millet will produce a crop if sown late, by using early

TABLE CIV.—Yield of Millets Sown in 1902.

Plot	Variety	Date Sown	Height, Inches	Yield Per Acre
				tons
1	German	June 2	36	3.75
2	Japanese	"	40	5.30
3	Siberian	"	38	3.65
4	Hog	"	36	2.90
5	Early Fortune	"	25	2.93
6	Hungarian	"	34	3.20
7	Common	"	34	3.33
8	German	June 16	28	3.30
9	Common	"	33	3.08
10	German	June 30	21	2.55
11	Common	"	25	1.90

varieties, it will not usually do its best unless sown near June 1st. The best yields of millet were obtained in 1902 on bottom-land broken in '97, on which sod had been fall plowed in '01. Table CIV gives the yield in tons of seven varieties and the result of late sowing with two kinds. The yields must be discounted slightly for dampness when weighed. The plots were cut Sept. 16th. Siberian and Hungarian are of similar earliness with common millet and were fully headed. The season being cold and late, the German millet even in plot 7 was not headed out yet when cut. Early Fortune is a hog millet but has twice proven very poor, perhaps due to poor seed, and the plot was nearly all weeds. The Japanese millet is quite coarse and tall which accounts for the large yields but does not improve its feeding value. Plots 10 and 11, sown June 30th are seen to be much lighter in yield than those sown on the 1st or 15th. Plot 9, Common, was headed and fit to cut, and plot 11 had begun to head, though the stalks were dwarfed. But the German millet on plots 8 and 10 was quite immature. Millet must be cured in the fall, and the task is not easy. This fact must be considered before sowing too much of it.

Peas are a success only upon rather heavy soil. In '96, on light sandy soil 9 varieties gave yield of from 8 to 13.5 bushels per acre. In '98, these varieties, grown on bottom-land underlaid with clay, yielded from 15 to 28.8 bushels per acre. They are valuable for hog feed, and where soil is favorable, may be grown for such purpose. The harvesting is difficult. Peas should be sown as early as possible. They cannot be sown too early, and if late sown they suffer from mould.

Corn.—The experiment farm has each year tested a number of kinds of flint and dent corn, amounting in all to 25 varieties of flint, and 30 of dent. No attempt was made to keep these strains separate as it would have been impossible, and they must be grown side by side for proper comparison. The effort has been to determine the exact status of Grand Rapids as a corn producing locality by finding out what kinds would ripen there year after year. The data obtained applies to other localities directly, only when the conditions are nearly the same, but can be used as a basis of compari-

son for other points by allowing for differences in temperature and moisture. Seed corn, more than all other crops, is directly dependent on the total amount of heat and sunshine during the summer. The latitude north or south increases or decreases this total heat and directly modifies the kind of corn it is possible to grow. Corn needs a dry air and sunshine. The presence of much moisture due to swamps and woods or the nearness of large lakes like Superior, with fog, retards its growth. There is a theoreical standard of production for each locality, representing the largest and the best corn that can be depended on to ripen annually at that point. All smaller and earlier kinds than this will not produce as much, and larger and later kinds will not ripen. This standard shifts with the locality and makes it difficult to breed varieties of corn in one place which will be the best kinds for other and different localities. It accounts for the failure of corn, which does well at one point, to ripen at another. But districts as they become better developed, have uniformly improved the kinds of corn raised, as every one knows. This is due first to the reduction of the excessive moisture in the air and soil, by drainage and clearing, and secondly, to selection and improvement of the corn itself. These indisputable facts are often quoted to prove that northern Minnesota will in time grow as good corn as Iowa. This loses sight of the influences of latitude which will forever confine corn growing within certain limits, beyond which local modifications cannot pass. From the facts at hand, it is safe to prophesy that in the latitude of Grand Rapids dent corn of reasonable size may sometime be grown with perfect safety, but it will always be smaller and less productive than that grown from Princeton south. In testing varieties, the standard kinds have been obtained from seedsmen, and in addition, as many strains as possible from farmers at various points in the northeasern counties. Of the twenty-five flints tested, table CV gives the results obtained with eight standard kinds in an average of between four and seven years trial with each variety.

TABLE CV.—Average Results with 8 Varieties of Flint Corn at Grand Rapids, Minn.

Color	NAME	Height of Stalk	Length of Ear	No. of Rows of Kernels	Probability of Ripening at Grand Rapids
		ft.	Inches		
White and Bl'k Mix'd	Squaw.....	3½	7	8	Ripe
White	North Dakota White....	4½	8	8	Ripe
Yellow	Gehn or North Dak. Yellow,	4½	8	8–12	Ripe
Yellow	Mercer..	6	9	12	Glazed
Yellow	Smutnose.....	6	12	8–12	Glazed
Yellow	Triumph.....	6	10	12–14	Glazed
Red	King Philip.....	7	10	8	Dough
Yellow	Longfellow.....	7	10	8	Dough

The squaw corn will ripen anywhere in the state, and planted about two feet apart, is fairly productive. The ears spring from the stalk near the base, which is troublesome in cutting.

North Dakota white flint is squaw corn, selected and improved as the table shows, and is preferable to the former.

Gehn or North Dakota yellow corn is the earliest yellow flint of any size. This type forms the basis of many strains of early yellow flint that are being ripened at the Wadena, Crookston and other points. There are several names for this kind of flint, and considerable difference between the strains, but the short stalk seldom growing over 5 feet high, with ears seldom more than 8 inches long, may be safely taken as an index of its earliness in every case.

The Mercer, with a slightly improved modification, (the Triumph), represents the next type of flint. The stalk reaches six, sometimes seven feet in length and the ears are 9 to 12 inches long. To this class the Smutnose belongs. These flints are not safe in this latitude, seldom reaching more than glazing stage before frost. The red King Philip and the yellow Longfellow, 8 rowed flints, with stalks 7 feet high and ears 10 to 12 inches long, are still later types and do not get beyond the dough stage.

Dent is not considered as early or reliable as flint for pioneer localities. Table CVI gives 18 varieties, grown from two to seven years, selected as types from the 30 kinds tried. As with flint, the size and height of stalk are the best indication of earliness. The Palouse corn obtained from Washing-

ton, is very early but so small as to be worthless except as a curiosity. The Station has no seed. The mixed dent known as Bergs, comes the nearest to ripening of any kind tried so far.

The ordinary dents, advertised as early by seedmen, will not ripen here. Illustrations are, Northwestern, Queen, Pride of the North, Early Butler, and others. The necessity for adaptation of varieties to locality is well shown in the table by the Whitecap dent. Seed which was raised at Princeton gave a stalk 8 feet high and did not form fullsized kernels before frost. The same variety, which had been raised for a few years at Aitkin, grew 6 feet high and gave kernels which were well dented by fall. The Berg's dent is a mixed strain of this variety grown at Mentor in Polk Co., and this reaches a height of about five feet, and in that locality ripens every year. These are all Whitecap dent. Names are useless in determining the kind of corn to plant. One must for his

TABLE CVI.—Average Result with 18 Varieties of Dent Corn at Grand Rapids, Minn.

Color	NAME	Height of Stalk	Length of Ear	No. of Rows of Kernels	Probability of Ripening at Grand Rapids
		ft.	inches		
White	Palouse	2½	6	12-14	Ripe
Mixed	Berg's, (Polk County)	5	8	12-16	Ripe
Whitecap	Aitkin	6	8-9	12-16	Dented
White	St. Cloud	5	8	10-14	Dented
Yellow	Western King, (Aitkin)	6	8	12-16	Dented
Yellow	Early Michigan	7	8	16	Late Dough
Yellow	Early Yellow Canada	6½	9	16	Dough
Yellow Whitecap	Minnesota King	7	8	8-12	Dough
Yellow	Huron	7	8	12-18	Late Milk
Red Strp'd	Northwestern	7	8-9	10-16	Late Milk
Yellow	Dakota Queen	7½	8	12-20	Late Milk
Yellow	Dakota Yellow	7½	8	16	Milk
Yellow	Queen of the Prairie	8	8	16	Milk
Yellow	Early Butler	8	7-8	16	Milk
Yellow	Pride of the North	7½	8	12-16	Milk
White	Rustler	7	8	12-16	Milk
Whitecap	Princeton	8	8-10	12-16	Immature
Yellow	No. 13	8	8-10	12-16	Immature

own locality, either take corn that has been raised there already, or experiment till he finds something he can begin on. It will be said that better kinds of corn can be ripened in this locality than appear in the tables. This is true in some seasons. The average season, however, will not permit of the ripening of such kinds and in a cold year like 1902, even the Berg's dent did not mature except in very favorable locations. The influence of moisture was shown by this variety. At Mentor, a comparatively open and settled locality, it does uniformly well. When the seed is brought to Grand Rapids, which is further south, but moister on account of the presence of more woods and water, the corn falls off in height and quality and has to re-adapt itself to the locality. Taken to a point such as Cloquet, where the influence of the lake is felt, though still further south, this corn will not ripen at all. To ripen corn two things are necessary—sandy, warm, well matured soil, and early planting. The seed should be in the ground by May 20th, preferably by the 15th. It may be frozen off, but the chance must be taken. Sandy soil is necessary for its freedom from excessive moisture, and consequent warmth. Manuring and frequent cultivation, to give the best conditions for growth, should then insure a crop if the season and variety allow it.

Potatoes.—Are naturally adapted to new land, northern latitudes and a light sandy or sandy loam soil. They are an intensive crop requiring more labor and giving greater returns per acre than most field crops. For both these reasons, potatoes must take a conspicuous place in the agriculture of these northern counties. The extent to which they should be raised over and above the needs of the farm will depend the market both local and general. Duluth and the range towns must be supplied, and they ship most of their stock at present from Chisago county or further south. The quality of the potatoes raised in the northern counties is excellent and should insure a good market for shippers. But there is occasional damage chiefly from wet weather causing rot, which affects the keeping qualities. Blight and other fungous diseases are not prevalent. The foliage is usually healthy and vigorous.

The most important lesson to be learned by a new-comer, in potato culture, is to avoid planting potatoes on heavy soil or low lying fields. The northerly latitude, with less heat to evaporate the moisture and warm the soil, combined with the probability of heavy rainfall at some period during season, renders the risk of injury from drowning out so great as to be prohibitive. Should there be no other land available, it will pay to ridge the land, and plant on the ridges, to allow the water to drain away. But when as is usual only a few acres are devoted to potatoes, the field selected should always be a well drained, sloping or elevated piece. The experience of the seven years planting on the farm illustrates this fact. The crop of '96 on light, drained soil, gave 203.5 bushels per acre for an average of two fields. In '97, a portion of the field was in a swale and the yield was cut down to 137.3 bushels per acre. In 1898 the crop was planted on a piece of new ground, broken the previous year, full of humus and of a loamy texture, underlaid with clay at 1 ft. to 2 ft. This was the best possible potato soil, with the exception, that it was not well drained, and water was apt to soak into it from higher ground. In order not to convey a false impression, it must be clearly stated that this piece was not swampy, had born heavy hardwood timber, consisting of oak, basswood and poplar and has since borne magnificent crops of grain and clover. The potatoes were injured on about one-half the piece, so that the yield on 8 acres averaged 132 bushels per acre while on the higher portions it gave just twice this, or 265 bushels per acre. The following season this whole field of 11.7 acres was again planted to potatoes, about May 24th. Heavy rains set in and not a sprout came up. Three weeks later, about 4 acres of the highest land was again planted to potatoes, which came up, but the rains continuing, the vines were drowned out and did not produce a crop.

As this season was wetter than usual, and in order to thoroughly test this question, 4.7 acres of this field were again planted to potatoes in 1900. This was the dry spring. The vines did splendidly until the later heavy rains set in, but the injurious effect of too much water at this late period (August) reduced the yield to 64 bushels per acre. The var-

ieties, planted on better drained soil, gave this year 209.6 bushels per acre. In 1901 the potatoes were planted on a sandy soil well drained with the exception of two corners, which were low. Upon these low spots, aggregating one-fifth of the field, the crop was completely ruined by rains, but the rest of the field averaged 158 bushels per acre.

The yield for 1902, when the crop was placed entirely upon well drained soil averaged for the fields, 202.9 bushels. This figure is as fair as any to represent the average possibility for potatoes, when mistakes are avoided. Under good management it may be higher, as is shown by the average yield of the potatoes grown in variety tests for six years. These plots naturally received the best location and treatment. They gave 242.7 bushels for all kinds, good and poor during that period. But the average of the fields, omitting the year of '99, was 149.6 per acre, the difference being due largely to drowning out.

The question of variety, with potatoes, is one of great importance, as there is a wide difference in yield. The difference averaged for 48 varieties, for two years, 214 bushels per acre, the highest yield being 246.3 bushels and the lowest, 132.3 bushels. Earliness, shape, color, size, keeping qualities and flavor give a wide range of choice, but between two varieties of equal merits in other respects, the question of yield is all important. It is not easy to test a large number of kinds for yield and be sure that the results really represent their relative producing power. The sensitiveness of potatoes to moisture in the soil causes a variation in yield every few feet, due to slight elevation or depression of the surface level, or change in the soil texture. There are other minor sources of variation not due to the potatoes, but the difference produced by moisture is far in excess of any other. The varieties to be tested should be grown in plots small enough to confine them all to a piece of ground which can be selected of fairly uniform character. If an equal number and weight of seed pieces be planted of each variety, an average of four or five years yields may be trusted to fairly indicate the best yielders, were it not for this variation due to soil moisture. There is a simple way of

equalizing this, though it has apparently not been tried so far to any extent by experiment stations. For the last two years, in our test with 52 varieties, a standard kind has been selected and planted every 7th row or 21 feet apart. The yields of these check plots were found to differ widely, but it was seen that where the check plots yielded best, the best yields of other varieties were obtained, and vice versa. The range in yield, even on the fairly uniform piece chosen in 1902, was from 282 bushels to 506 bushels for the standard variety. With such difference as this due to other causes than the quality of the varieties, no amount of averaging could be depended on to give truthful results. But with this

TABLE CX.—Yields of 48 Varieties of Potatoes. Average for Two Years.

KIND	Gross Yield	Per Cent Market-able	Net Yield	Earliness	Quality
Early Michigan	363.4	95.3	346.3	Early	Fair
Prizetaker	377.4	91.0	343.6	Med. to Late	Very Good
Northern Spy	352.0	93.9	330.5	Late	Good
Maggy Murphy	345 4	94.6	327.0	Late	Good
Wonderful	337.7	94.3	318.6	Late	Very Good
Rose No. 9	327.1	94.2	308.0	Late	Fair
State of Maine	332.4	92.5	307.7	Med. to Late	Good
Reeve's Rose	319.8	95.8	306.5	Late	Fair
Early Fordhook	335.7	91.0	305.4	Early	Good
Lincoln	324.6	93.4	303.3	Late	Good
Delaware	321.3	94.3	303.1	Med. to Late	Fair
Polaris	310.8	97.0	301.4	Med. to Late	Good
Carmen No. 3	310.2	96.6	299.5	Late	Good
Uncle Sam	305.5	96.3	294.3	Med. to Late	Good
Bartlett	326.1	89.6	292.3	Late	Very Good
American Wonder	309.6	93.3	289.0	Late	Very Good
Burbank	326 0	87.6	285 5	Late	Very Good
Early Sunlight	308.3	92.3	284.8	Medium	Good
Carmen No. 1	304.7	90.6	276.3	Medium	Very Good
Chase Seedling	301.3	90.8	273.6	Med. to Late	Good
Sislers	286.9	94.6	271.6	Late	Fair
Dakota Red	289.0	93.5	270 4	Med. to Late	Good
Early Triumph	310.4	86.6	268.9	Early	Good
Red American Wonder	274.7	97.2	267.0	Late	Very Good
White Ohio	284.9	92.9	264.9	Early	Good
Vanier	286.3	90.7	259.8	Late	Poor
Early Vaughan	287.3	90.4	259.7	Early	Very Good
Seedling No. 230	279.8	92.2	257.9	Med. to Late	Good
Pride of South Dakota	276.4	92.6	256.0	Med. to Late	Good
Seattle	278.7	91.8	255.9	Med. to Late	Fair
Red River Acme	282.4	89.3	253.4	Early	Fair
White Beauty	282.4	89.0	251.4	Med. to Late	Very Good
Rural New Yorker	266.0	97.7	250.9	Late	Good
Irish Cobbler	266.4	91.3	243.4	Medium	Good
Sir Walter Raleigh	246.2	94.2	232.0	Late	Fair
Main Crop	255.1	90.4	230.7	Medium	Good
Early Fortune	251.8	89.7	225.9	Medium	Fair
Livingston	242.5	91.2	221.3	Late	Fair
Seneca Beauty	225 8	94.5	213.4	Late	Very Good
Extra Early Pioneer	244.0	84.0	205.1	Early	Fair
Garfield	220.1	92.9	204.4	Med. to Late	Good
Early Andes	217.1	94.0	204.1	Early	Poor
Early Ohio	232.8	87.6	204.1	Early	Good
Herrington Peer	227.2	88.5	201.2	Med. to Late	Good
Early Norther	229.2	87.5	200.7	Medium	Good
Early Six Weeks	210.6	89.6	188.8	Early	Fair
Harvest Queen	156.2	89.4	139.7	Med. to Late	Good
Salzer's Million Dollar	151.5	87.3	132.3	Late	Fair

series of check plots, whose yields may be plotted on paper, and the "value" of each intermediate plot thus obtained by means of a curved line, it is easy to figure the yield of each variety in per cent of the check row. If the average yield of all the check plots is adapted as the standard yield, and the yield of each variety corrected by multiplying this figure by the percentage for the variety, the results must be as nearly accurate as can be obtained. The tests for the first five years were not conducted on this principle. During this time some 30 kinds were tried. In 1901, many new varieties were obtained and the best of old kinds saved. The comparison both of these and the new kinds is thought to be so much more accurate for the two years, that figures for previous yields are omitted. Table CX gives the average yield for two years of 48 varieties, showing the total yield and the yield of marketable tubers, on which the rank is based. The main crop potatoes have been planted between the 23rd of May and 1st of June depending on the season. They are dug between Sept. 25th and Oct. 10th. The very late kinds do not ripen before frost, and where other things are equal preference should be given to the second early or medium late varieties.

Where there is so much new land to be brought under cultivation, potatoes will usually be planted on such soil, and with good results. There is a certain amount of work to be done in breaking and harrowing, and the planting and cultivation of potatoes helps to work down the surface. On such land there will be very little if any scab, even from scabby seed. But no crop, not even potatoes, will give best yields the first year, nor until the soil is well rotted and worked up. This was well illustrated in 1902. A field which had had the timber cut from it in '98, and had since been closely pastured by sheep, was broken late in the fall of 1901. In the spring it was cross plowed and planted to potatoes, yielding 175 bushels per acre. A strip along one end of this field had been plowed early in the spring of 1901, sown to oats and pastured off by sheep during the summer. This was plowed with the rest in spring of 1902, and the yield on the piece was at the rate of 342 bushels per acre or nearly twice as much. A part of this difference may be

charged to more favorable slope and situation, but it was chiefly due to the more thorough preparation of the soil by summer fallowing and pasturing. This piece was quite sandy.

It is a great temptation to plant potatoes year after year, on a well prepared piece, especially in a garden, or when the farm is not being cleared up rapidly. But this is usually rendered impossible by the appearance of scab. Scab is never present in new soil, and is brought into it by the potatoes planted there. It is a microscopic plant, which feeds upon the potato. Its spores or seeds fill the soil, and when succeeding crops are planted, there is so much scab in the soil that the crop is completely covered and largely ruined. In new land the only scab present is what is on the seed pieces, which is not enough to affect the crop. The second crop on the same soil may show considerable scab, but not usually enough to spoil its sale. But let potatoes be planted a third year on this land, now thoroughly infected, and the crop will be almost worthless. If for any reason it is intended to use certain land for potatoes continuously, scab may be entirely kept out if done from the start. The seed potatoes should be soaked every spring before planting, unless they are absolutely clean, in a solution of corrosive sublimate, 2 oz. to 8 gallons water, for an hour. This destroys the scab on the potato and there will be none on the crop as none exists in the soil. This method is ineffective, on soil already filled with scab, for one cannot soak the ground with sublimate. The possiblity of keeping out scab has been demonstrated on a plot, where potatoes so treated have been planted for three consecutive seasons without a trace of the disease appearing in the crop. But scab will sometimes appear in spite of these precautions. In this case it always comes from the manure of animals which have eaten scabby potatoes, or from parings or slops containing scab. A new piece, in potatoes the first time, for which the seed had been treated, was so infected in 1902 by hogs, so that considerable scab appeared in the crop. These facts are given that the nature of scab may be thoroughly understood and not as an inducement to grow potatoes continuously on the same soil. The scab itself is a protest against

such farming and even if kept out, blight and bugs get worse, and the yield falls off through the soil getting out of condition and losing its humus and fertility. On the same plot treated three years for scab successfully, the yield in 1901 was 131 bushels compared with an average of 244 bushels on four other plots which for the two years previous had been planted to grain and grass. When ground becomes scabby it remains so for several years even if no potatoes are planted in the interval. Where potatoes cannot be planted on new land they can always be put upon a piece which has not grown them for some time. Sod land is excellent if rightly treated. Old sod should be rather deeply plowed in the fall and worked up for the potatoes. Sod which bore clover the preceding year and had both crops cut, is not of sufficient toughness to interfere with the growth of the potatoes and may be spring plowed, planting them in every third furrow next the edge. This was done in 1902, and gave 230 bushels per acre. The richness of the land greatly affects the size of the yield. In '96, on two fields which had received the same treatment previously, the one dressed with stable manure gave 231 bushels while the other field yielded 183 bushels per acre. The difference in yield before noted, on the plot continuously in potatoes, with other plots on which the crops were rotated, is due largely to the better condition of the soil of these plots due to adding sod or manure. Stable manure has a more beneficial effect, and lasts longer in the soil than the prepared commercial fertilizers. A comparative test with potatoes on two plots that had grown oats for two years previous, using about the same amount of fertilizer according to the analysis as was contained in the manure used, gave a yield of 282.5 bushels for the manured plot, and 180 bushels on the plot with fertilizer. In raising potatoes, big yields pay, and with no crop will it pay better to expend thought, labor and manure, in the proper selection and preparation of the soil.

Roots may be made quite an important crop for stock feeding in this section. Their place as a feed is more as a supplement to the main ration than a substitute. Fed in small quantities with hay or fodder, the roots keep the system in good condition, improve the digestion, and cause the

Root Varieties.—Lower Northeast Field.

animal to turn its other feed to better account. They may be substituted for other feeds if necessary, in which case much larger quantities must be fed, as there is about 90 per cent water in roots as against 13 per cent in hay.

The root crops on the farm have not been uniformly successful, as they have twice suffered from water on fields otherwise well suited to roots but too low to be safe through a wet spell. It has been shown too, that sandy land cropped for some time without sod, will not raise a large crop of roots. But root crops may be grown under wetter soil conditions than potatoes.

Rutabagas have uniformly given the largest yields and are adapted to the widest range of soil conditions. They are often sown and produce well on breaking and new land is especially favorable for their development. Mangels require not only better soil for large yields, but it must be in better tilth. The results obtained will for these reasons, not average as well as for rutabagas. Sugar beets never yield

as well as mangels in this section. Carrots do well but do not yield as heavy a crop as the other roots.

In 1900, the roots were raised on soil that was well suited to all kinds of roots, and the yields obtained were representative not only of the normal yield of roots under favorable conditions, but of the relative productiveness of the different kinds. They are given in table CXI. These relative yields are about as fair as general comparison as it is thought possible to get, eliminating the influence of soils and other conditions.

TABLE CXI.—Yield of Varieties of Roots in 1900.

Kind	VARIETY	Yield, Tons per acre	Average for Class
Rutabaga	Prizewinner	26.1	
	Sweet German	23.7	
	Monarch Swede	23.5	
	Carters Swede	22.8	24.0 Tons
Mangel	Red Globe	19.9	
	Golden Giant	19.7	
	Mammoth Long Red	18.3	
	Tubers Gate Post	17.0	
	Champion Yellow Post	16.4	
	Golden Tankard	13.4	17.6 Tons
Sugar Beet	Klein Wanzlebener	14.7	
	Vilmorin	11.9	13.3 Tons
Carrot	Victoria, White	8.5	
	White Belgium	7.6	
	Mastodon, White	7.0	
	Yellow Belgium	5.6	7.2 Tons

In 1901 the crop was grown on poor droughty soil, made so by lack of humus from cropping continuously to cultivated crops. Under these conditions rutabagas gave 10.1 tons per acre, and carrots 11 tons, while mangels yielded 6.2 tons per acre.

The season of 1902 was too cold and backward for largest yields of roots. The average, in fair soil, was, rutabagas 17.2 tons, mangels 7.5 tons, sugar beets 6.4 tons and carrots 9.2 tons per acre.

For two years the roots have been sown at two different dates to test the effect on the yield. In 1901, rutabagas sown May 15th yielded less than those sown June 1st, but in 1902 the early sown was the heaviest crop, due to the slow season. The late crop yielded 14.7 tons, and the early

sown gave 19.7 tons or 34 per cent more. The yield of late sown rutabagas in 1901 gave 26 per cent more than the early sown, and this result will probably be obtained in an ordinary season. The mangels have always given larger yields when sown early—the difference averaging 1.7 tons in favor of the early sown. With carrots and sugar beets the results have also favored early sowing.

Rotations.—The necessity for growing the principal crops of this section, as grain, grass, potatoes and cornfodder, in rotation, in order to maintain the yield of the crop and the fertility of the soil, has been pointed out for each crop. It is perhaps the most important question connected with our farming, at least the one in which mistakes are most apt to be made. The amount of land devoted to grain, grass and potatoes or corn respectively, will vary with the amount of stock kept, nearness to market and other factors. But the farmer generally knows about how much of his land he would like to have in each kind of crop. We have seen how largely the yield of grass may be increased by plowing up the meadow at the end of two or three years and seeding down a new piece, and how oats or cornfodder or potatoes give bigger crops on sod than on land under continuous cultivation. A proper rotation which will benefit the soil, depends almost absolutely on the plowing under of sod, and unless one is willing to plan his farm management with this end in view, he can do very little of real value, by rotating his other crops. A perfect rotation cannot be devised for a new farm which is being cleared up but the principle can be applied on any farm and the details altered every year if necessary, to meet the conditions. A perfect rotation is a system by which the farm is divided into a definite number of fields of nearly equal size, and a rotation of crops grown, so that there are as many different crops as the farm has fields. Each crop is grown on a different field each year, in a regular order, so that the acreage of each crop each year is the same. An example of a four year rotation, would be corn or potatoes, then oats seeded down, and meadow two years, the fifth year bringing it back to the starting point with corn again. Should this rotation be perfected for a farm, there would be four fields, two of

which would be in meadow, one in oats, and one in corn each year. The following year the corn or potatoes would be upon the fall plowed meadow which had lain two years, the oats on the corn ground of the previous year, and the oat field which was seeded down would be in meadow. And so on until the fifth year would see the crops on the same fields as at first. This general principle can be modified in countless ways to meet different conditions. One way is to have two sets of fields on which rotations of different lengths are practiced.

To illustrate this principle of perfect rotations, a set of eight plots was laid out in 1900 on good soil, and two rotations were started, a three year and a five year. In this case it took but one year to bring the proper crop upon the proper fields so that in the second year of the rotation, each crop was where it belonged. The five year rotation was cornfodder, for which the land was manured, then wheat seeded down, meadow two years, then oats followed the sixth year by cornfodder, thus beginning the rotation again. The three year course was oats seeded down, clover with the second crop plowed under, and potatoes the third year on

TABLE CXII.—Showing the order of Cropping Eight Plots brought under a Five Course and Three Course Rotation.

1	6	7	8
1900—Wheat.	1900—(Cornfodder.)	1900—Potatoes.	1900—(Oats.)
1901—Clover, Two Crops.	1901 {Manure Cornfodder.}	1901—Oats.	1901—Potatoes.
1902—Timothy.	1902—Potatoes.	1902—Clover.	1902—Oats.
1903—Oats.	1903—Oats.	1903—Potatoes.	1903—Clover.
1904—Manure Cornfodder.	1904—Clover.	1904—Oats.	1904—Potatoes.
1905—Wheat.	1905—Potatoes.	1905—Clover.	1905—Oats.

2	3	4	5
1900—(Wheat.)	1900—(Wheat.)	1900—Oats.	1900—Manure Cornfodder.
1901—Clover.	1901—Oats.	1901—Manure Cornfodder.	1901—Wheat.
1902—Oats.	1902—Manure Cornfodder.	1902—Wheat.	1902—Clover, Two Crops.
1903—Manure Cornfodder	1903—Wheat.	1903—Clover, Two Crops.	1903—Timothy.
1904—Wheat.	1904—Clover, Two Crops.	1904—Timothy.	1904—Oats.
1905—Clover, Two Crops.	1905—Timothy.	1905—Oats.	1905—Manure Cornfodder.

the sod. In table CXII is shown the crops as they are being grown upon these eight fields, and the crops which were grown in 1900 and 1901 to bring the fields into proper rotation. The crops not in the rotation, but necessary at first to prepare for the proper crop, are in brackets. The field in 1899 was clover meadow and the crops of 1900 were planted on a fall plowed second crop of clover. Were a farm of 80 acres put into this rotation, 30 acres would each year be in meadow, of which 20 acres would be in clover, and 10 acres timothy. There would be 20 acres of second crop clover, half of which would be plowed under, and the other half cut or pastured. Thirty acres would be in grain, 20 of oats, 10 of wheat. Ten acres would raise cornfodder, and this amount would be manured each year, and 10 acres would be for potatoes. Had the crops actually harvested on the tenth acre plots in the experiment in 1902, been gathered on such a farm it would have yielded in 1902, 867 bushels of oats, 303 bushels of wheat, 39.2 tons cornfodder, 55.8 tons of first crop and 5 tons second crop clover, with 10 acres plowed under, 17.3 tons timothy, and 2925 bushels potatoes. At 30 cents, the oats would be worth $260.10, the wheat at 60 cents, $181.80. Clover at $8.00 per ton, $486.40; cornfodder at $4.00, $156.80; timothy at $10.00, $173.00, and potatoes at 25 cents $731.25, or a total of $1,989.35. Neither the yields quoted, nor the prices, are excessive for ideal conditions. But the average yield for any farm of 80 acres would necessarily fall below the yields obtained on these small tenth acre plots.

This does not diminish the force of the illustration, for on as much of the land as is of equal value, crops as good can be grown, if the sod is plowed and the crops rotated under a similar system. Not even on the experiment farm is it possible to bring the fields into a fixed rotation like the above, and neither is it necessary. But the general plan can be adhered to, and the details modified to meet the circumstances. A single, general rotation may be best. Such a one, of four years, is practiced on the farm. Grain crops are all classed alike and make up one year. Meadow is given two years and cultivated crops including corn, cornfodder, potatoes and roots makes the fourth. The fields, which are

much cut up by roads, ditches, and plots, are classed into four groups of approximately equal productive area. As new land is cleared, it is classed in with one or the other of these groups as circumstances dictate. The rigid four year sequence is seldom followed on any of these fields, but the crops are always planned to bring the field back into its place in the rotation if they depart from it. If the clover catch should fail, a second grain crop would be raised, and the fields seeded down again, but allowed to remain only one year, instead of two in meadow. Should it be desirable to plow under the second crop of clover, the field would either be brought into meadow again a year sooner and allowed to lie three years or an extra grain or cultivated crop would be raised on it. Millet has sometimes been raised in place of potatoes, and other changes made. The possibility of such modifications makes the system elastic enough to meet any condition that may arise, and at the same time the general plan can be closely followed, guess work done away with and the numerous beneficial results of rotation be permanently secured. The main point is to have a general plan to suit the conditions of the farm, and then work steadily towards it. Examples have been given of three, four and five years rotations, and of two rotations on the same farm. These are only a few of the many plans that may be adapted, but the simpler they are the better. The four year rotation of cultivated crops, grains and meadow two years, lends itself to more changes and conditions than any other, which is why it was adapted, or rather forced itself upon the experiment farm. The proportion of the various crops raised under this rotation seems to more nearly and easily approximate the general needs of the farmers here than other rotations. In fact, it serves as the type of rotation in this section and all other successful rotations are mere modifications of this one. To test the effect of different methods of rotation in a thorough manner both on the composition of the soil and the yields produced, twenty-four plots were laid in 1900, on each of which a different rotation was started. Sixteen of these include grass in a three four or five year course. The others are planned without grass depending on manure, or the plowing under of rye for fertilization. Some

are purposely wrong in principle as when oats or potatoes are raised year after on the same soil. This experiment can be run as long as the farm lasts. The results of the different methods pursued will become more and more evident each year, until they finally stand as unmistakeable object lessons in proper methods of rotation.

Clearing Land.—There is no area of any extent in the northeastern counties of Minnesota, but what is or was timbered or swampy. All land except natural meadows must be cleared before it can be farmed.

Fire has done an enormous amount of work in clearing land. In many sections, destructive fires have so reduced the expense of clearing that they have given an impetus to

Sheep clearing land of small brush.—Sheep Pasture.

settlement. But it may be doubted whether this benefit is not more than offset by the injury done to the soil by burning and destroying the humus and litter on its surface. The injury is greatest on sandy soil, as it has most need of the humus. Severely burned sandy land, while easiest of any to

clear, should be regarded with suspicion as its fertility may have been greatly impaired by the fires. On heavier soils the injury is not so pronounced and here the fire may have been of great help in reducing the amount of work necessary in clearing.

In clearing standing hardwood timber or small pine, as jack pine, the trees may be made to aid by their weight, in pulling the stump by cutting the roots and pulling the tree over. This needs a double block and chain or rope, with a chunk or log laid next to the stump to lift the roots clear in the fall. This chain is attached for the pull as high up the tree as possible. More often the timber, especially pine, has been or will be cut, and the stumps left. The ground between them is cleared and broken and either cropped or seeded down until the stumps are removed. In brushing and subduing the land, sheep are an aid in keeping down sprouts about certain classes of hardwood stumps, but chiefly in destroying small brush and in their effect on the soil. They will not pull down or kill brush that stands five feet high or over. This will have to be cut. But the roots in the soil rot, and its wildness is mellowed by the tramping, grazing and manure of the sheep. Soil that has been closely pastured for 3 years, by sheep, on the farm was easily broken by a common cross plow, and raised 200 bushels of potatoes in 1902, when broken late the preceding fall. Thus it is seen that sheep can do only a limited amount of work in clearing, but as they are getting a living at the same time, their services are so much clear gain to the work. The stumps rot more quickly when pastured about than if grown up in brush. The cost of brushing, picking up and burning exclusive of stumping or removing standing timber will vary from $2.00 to $8.00 per acre. For gathering fine brush and rubbish an iron rake may be used whose teeth are bent back at the tips to run easily over the surface. A blacksmith can make one, mounting the teeth in a wooden back for lightness.

Stumping is the chief expense of clearing. With hard wood and small sappy Norway or Jack pine, the stumps rot in three or four years, and when pulled then do not bring up much dirt, come easier and yet are solid enough not to break off. If left much longer many of them will break, leaving

Partially cleared land in sheep pasture.

the root in the ground, while if pulled green the fibrous roots bring up a mass of earth difficult to loosen. This indicates that the cheapest method is to pasture the land for three or four years after the timber is cut before pulling the stumps. Pine stumps containing heartwood do not decay appreciably though the small roots rot off. They are apparently just as sound after twenty years as when cut.

In pulling stumps much can be done with blocks and chain or cable, in lieu of a stump puller. If the larger stumps are split with dynamite and the roots cut, a good team with two blocks will pull out nearly everything. In no case does it pay to pull very large pine stumps whole. After they are pulled they are very hard to handle. By splitting them with dynamite the pieces may be pulled separately. This allows the use of a small stump puller which can be dragged about and set up quickly and easily. Dynamite does very efficient work on stumps in thus splitting them and in blowing most of the dirt off the roots so that they will burn more easily. It is inserted under the stump in a hole made in the dirt with

a crowbar, or preferably a dirt augur. The amount depends upon the size and kind of stump, but four sticks will split up a very large pine stump, and one stick or one-half pound will take out a good sized poplar. Too much as well as too little can be used, and for economic work the dynamite should never be entirely depended on but used in connection with the stump puller or block and line. If a good, small or medium stump puller can be afforded it is probably the cheapest method and requires less labor than the block and line. The method employed must be determined by means, circumstances and judgment. The cost of pulling, piling and burning the stumps will vary between wide limits, depending on the thickness of the timber, the soil, age of stumps, kind and size, but in no case will it be low where the land was heavily timbered. A hard wood piece, mostly poplar, very thick, with about ten small standing pines per acre, was stumped with block and line, piled and burned, for $19.00 per acre, which did not include the removal of the brush and logs. Six acres heavy tamarac cost for stumping by hand and with block $18.60 per acre. Heavy pine cannot be stumped for much less than $25.00 to $30.00 per acre, using dynamite and stump pullers, while some lands covered sparsely with second growth hardwood, as poplar, may be stumped for from $6.00 to $10.00 per acre.

Breaking is best done in June or early July. The roots of the brush and wild plants at this period have very little food stored up and die, while in the fall they are well stocked with food and will sprout and grow in the spring if there is a chance. It will not often pay to backset as with prairie sod, as the furrow is necessarily uneven from roots and inequalities in the surface and will be turned rather deep. It may be worked down on the surface in the following spring, and planted to potatoes, cornfodder or oats. With early plowing, especially on soil that has been mellowed by pasturing with sheep cross-plowing or back-setting may be feasible in the fall or spring thus getting the soil worked up sooner.

Swamp Land.—A large amount of land in the northern counties is swampy. These swamps fall into two classes—those which grow timber and those on which neither timber or grass grows, except stunted spruce.

The timbered swamps grow either cedar, tamarac or black ash. The timber shows the presence of a mineral soil, and the possibility of making these swamps into hay or farm lands by clearing and drainage. Hay bottoms, or beaver meadows show the same conditions by a luxuriant growth of grass. The remaining type of swamp, which is not found along water ways but back from the streams is what is known as muskeg. It may always be recognized by the absence of large trees or tall grass. It grows small black spruce, which may be one hundred years old, and less than an inch thick. The surface of the muskeg is a mat of sphagnum moss interlaced with the roots of two dwarf shrubs which bear small entire shiny leaves. Often fly catcher plants are found and a few species of grass resembling wire grass. These swamps are sometimes found filling small depressions, at other times stretching over miles of territory. The soil is an accumulation of the decayed remains of the moss chiefly and has little if any mineral matter in it. When perfectly dry it will burn up, but it seldom gets dry as the level surface is always more or less saturated and flooded with water. The moss has the power of retaining a great deal of water and stays damp while there is any water within its reach.

It is often stated that these muskegs will make the finest hay meadows in time similar to those in the more southern districts of the state. This is a dangerous generality especially if it leads to placing any monetary value on such lands. It may be doubted whether these swamps in the southern portion were formed from the accumulation of decayed moss. But granted that they were once similar, there is now a wide difference. The first problem is how to get the muskeg into condition for grass. If there is an outlet and a fall it can be drained. Ditches are easily dug in the peat at a cost of about one half of what the same would cost in soil, but to drain a piece of bog it is not enough to provide an outlet ditch. The ditches must surround the piece to prevent water flowing into it as it permeates so slowly that no amount of ditching will otherwise keep it dry in a wet season. Then comes the removal of the moss, for while it remains nothing else can grow. Burning would appear to be the cheapest

way but experience shows that unless so dry that it is apt to burn holes, the damp moss will not burn off evenly and not at all in a wet season. If it is kept up for several years, burning may finally get rid of the moss on drained portions. To remove the moss mechanically as was done on a portion of the swamp on the experiment farm requires an outlay of about $75.00 per acre. Granted that these swamps will grow grass, it is a question whether it will pay to try to subdue them for that purpose. But if in addition the ultimate result is doubtful, it becomes an economic mistake to expend any energy on their reclamation, which might be put upon clearing land of which there is no doubt. These facts are not given at random. The experiment farm has worked for seven years upon a small muskeg, ten acres in extent. A portion of the swamp has been drained since '96 and another piece since '98. On both pieces the moss was stripped off after failing to get rid of it by burning. A horse and three pronged hook was used to tear up the tough bunches of moss and shrubs and haul it off. The ground was broken and left to rot. But after three and five years respectively the swamp has not been gotten into tame meadow. It would be unsuitable for any other crop but hay in any case on account of its coldness and loose texture. The conclusion founded on these facts is that it will not pay farmers to buy or try to subdue these muskegs, and loose general statements drawn from experience in other sections will not be accepted as proof to the contrary.

To more thoroughly investigate the character of these soils, ten carefully selected samples were sent to the chemist of the Experiment Station at St. Anthony Park, his official report is herewith submitted.

REPORT ON COMPOSITION OF MUSKEG SOILS.

Ten samples of muskeg soil were submitted to complete chemical analysis. The samples were taken in the fall of 1902 by Superintendent Chapman by whom the following description of the samples is given:

Sample No. 1.—From a large muskeg; a strip was drained in '97 and cleared of moss and shrubs in 1900, and the sample taken just below the surface.

Sample No. 2 is taken from the same locality as No. 1, but was taken at a depth of 2 ft. 6 in. below the surface.

Sample No. 3 is from a large muskeg, natural state, taken just below the surface. This sample represents a raw undrained muskeg which has never been brought under cultivation.

Sample No. 4 is from the same locality as sample No. 3 but was taken at a depth of 3 ft. from the surface.

Sample No. 5 is from the large muskeg west of No. 1, where it was drained but not cleared. The sample was taken just below the surface.

Sample No. 6 is a muskeg soil cleared of moss in 1899, drained and plowed. The sample was taken just below the surface.

Sample No. 7 is from a small muskeg, drained, cleared and partly grown over with grass; the sample was taken from a place where blue joint grew vigorously.

Sample No. 8, muskeg from the same locality as No. 7, taken at a depth of 10 inches.

Sample No. 9, muskeg from the same locality as No. 7, taken at a depth of 20 inches.

Sample No. 10, muskeg from the same locality as No. 7, taken at a depth of 30 inches.

From the description of the samples, it will be observed that there are represented muskeg soils in the natural state, No. 3; drained, No. 5; drained and cleared, No. 1; drained, cleared and plowed, No. 6; and producing blue joint grass, No. 7.

Difficulty was experienced in the sampling and preparation of the soils for analytical operations because of the large amount of fibrous vegetable matter which they contained. Only a very small amount of fine earth was obtained. Analysis of the fine earth and of the fibrous material showed that there was practically no difference in the amount of volatile, principally vegetable, matter in each. The coarse fibrous material had practically the same composition as that which passed through a one-half mm. seive.

All of the samples gave a decided acid reaction. Attempts were made to determine the total and relative amounts of acid in the various samples. All of the known

methods for the determination of acidity of soils were tried, but satisfactory results were not obtained with any of the methods, direct titration with standard alkali solution gave the most satisfactory results. It was found that a gram of dry soil contained organic acids equivalent to from .02 to .03 grams of hydrochloric acid. There is nearly 2 per cent of acid in terms of hydrochloric acid in these soils. The difference in the amount of acid in the various samples was small, the soils which had been drained and plowed showing a tendency to contain slightly less acid than the raw undrained muskegs. Cultivation appears to have lessened the acidity. This is due undoubtedly to the decay of vegetable matter and organic acids.

The amount of volatile matter in all of the soils is exceedingly high, ranging from 85 to 95 per cent, the largest amount being present in the raw muskeg sample at a depth of 3 feet where but little decay had taken place. The amount of mineral matter in the samples ranged from about 5 to 15 per cent, and is no more than is ordinarily found in agricultural crops. Straw will frequently yield more ash or mineral matter than is found in some of these samples. The sample which produced the blue joint hay contained 85 per cent of volatile or vegetable matter while the raw muskeg contained from 90 to 95. Draining, stripping of moss, plowing and other treatment which the muskeg received has reduced the vegetable matter in sample No. 7 to 85 per cent. From the analysis of these samples, it would appear that a portion of the vegetable matter must first undergo decay before a natural grass crop can be produced and such a crop can not be produced when more than 85 per cent of vegetable matter is present.

The amount of nitrogen in all of the soils was high, ten times more than is found in soils from the same locality but of different origin. In bringing the muskeg into condition so as to produce blue joint, the amount of nitrogen is apparently reduced. Since nitrogen is one of the elements which forms a part of the vegetable matter of soils, a loss of vegetable matter would necessarily be followed by a corresponding loss of nitrogen.

The amount of humus materials in the soil ranges from

22 to 48 per cent. Since humus represents the vegetable substances more thoroughly decayed, it is readily understood why more humus is found in samples 6, 7 and 8 than in 1, 3 and 4. The vegetable matter in the thoroughly drained and cultivated soils is more completely decayed.

The amount of mineral matter in all of the soils with the exception of 9 and 10 is small. When the soils were burned, a fine grey ash-like residue was obtained. This mineral matter contained quite a large amount of sulphur due undoubtedly to the sulphur being in chemical combination and forming a part of the organic matter. The nitrogen and sulphur content of the soil would indicate that a large portion of the nitrogen was in forms allied to complex proteids. The amounts of iron and aluminia in these soils are small. The vegetable matter contained an appreciable but variable amount of phosphoric acid and also a fair amount of both potash and lime.

These soils are, as indicated by the analyses, entirely different in chemical composition from ordinary arable soils. The principal change which they undergo while being brought under cultivation is decay of the vegetable matter followed by a corresponding decrease in acidity. As to whether these soils are suitable for grass lands must be decided largely by local conditions, considering principally drainage and expense involved in bringing the soils into condition to produce hay. Soils as No. 7, contain a large amount of nitrogen and a fair amount of potash and lime. When brought under cultivation such soils are generally found to be the most suitable for the production of hay. Applications of wood ashes, lime or marl would undoubtedly prove beneficial on these soils in neutralizing the organic (vegetable) acids, and supplying active alkaline matters which appear to be deficient.

Soil No.	Description of Samples	Volatile Matter; (mainly vegetable)	Nitrogen.	Humus (partially decayed vegetable matter.)	Insoluble matter; (mainly sand and insoluble silicates.)	Iron and Aluminia.	Lime (Ca O)	Magnesia (Mg O)	Sulphates ($S O_3$)	Phosphoric Acid ($P_2 O_5$)	Potash ($K_2 O$)
1	Large muskeg-drained, stripped cleared of moss and stumps..	92.25	2.91	26.65	6.00	.76	.41	.12	.11	.22	.15
2	Same as No. 1, 2 feet 6 in. deep.	93.78	2.36	27.35	5.69	.31	.22	.08	.07	.02	.19
3	Large muskeg, natural state.....	94.04	2.45	23.42	4.11	.79	.47	.17	.12	.19	.32
4	Same as No. 3, 3-feet deep.....	95 13	1.50	22.78	3.23	.34	.25	.13	.08	.09	.26
5	Large muskeg, drained but not cleared.....	91.69	2.49	25.13	5.84	.96	.40	.19	.20	.24	.41
6	Portion south of ditch, cleared of moss 1899, plowed and drained.....	90.14	2.43	30.40	8.40	.70	.29	.08	.10	.13	.27
7	Small muskeg, cleared and grown up in grass sampled where blue joint grew vigorously.....	85.31	1.98	31 42	12.81	.99	.18	.06	.17	.03	.32
8	Same as No. 7 10-in. deep.....	86.40	2.76	48.01	12.45	.61	.29	.10	.20	.03	.23
9	Same as No. 8, 20 in. deep.....	46.16	1.36	27.29	52.55	.84	.26	.04	.07	.05	.27
10	Same as No 9, 30 in. deep.....	8.59	.19	4.39	88.71	.15	.37	.04	.01	.04	.28

HARRY SNYDER.

It is to be noted that on the spot where sample No. 7 was taken, blue joint grass grew vigorously. This had been drained since '96 and cleared of moss since 1899, and 1902 was the first year that the grass grew on the spot. Special attention is called to the fact that at this place the mineral subsoil was only about 2 feet below the surface and blended with the muskeg fenn below.

Sample 2, taken at 2½ feet, shows no mineral soil, and while this spot has been drained and cleaned an equal length of time, it is non-productive. It may therefore be inferred that where the peat is less than a foot in thickness it will be more easily subjugated than where it is from two to three feet deep. The depth can easily be ascertained with a post augur.

Weeds.—A new farm theoretically should have no weeds. But they cannot be kept out very long. There is very little grass seed that does not contain some few weed seeds. Oats

sometimes sold for seed oats may contain weed seeds. Hay and feed contain them. In this way most species of weeds are quickly brought into a new region. While good cultivation will keep most kinds in check, it is not well to depend on this in the case of mustard. If this weed once gets into the soil it will require years of care and work to eradicate it. The seed will lie in the ground when plowed under until it is turned up again near enough to the surface to sprout. Great care should be taken not to sow mustard with grain, and should it appear it must be pulled out at once. In this way the farm may be kept clean of it from the start. For lack of these precautions many new farms in this region are already as badly infested as farms in other sections.

Sheep.—No class of live stock has such an important relation to the development of a new farm as sheep. This is due to their habit of browsing on brush.

The experiment farm has maintained a flock of about seventy five sheep for five years, and used them in clearing up new land. The experience gained has been very useful. It is often claimed that sheep will live entirely upon brush. It is true that they can do so, but they will not do their best under such conditions. This fact should be emphasized. Should it be necessary to confine sheep entirely to brush, they will be apt to get poor, and the lambs will not make the best growth, as an all brush pasture seems to shorten the milk supply of the ewes. This has been amply demonstrated for two different summers with the flock on the farm. The sheep will destroy the brush quicker when confined upon it. It therefore becomes a question of which is the more important end to be attained. Should it be impossible to furnish the sheep with any pasture except brush, one must not expect the sheep to get fat upon it, for they will seldom do so unless there is a large amount of grass or peavines in the pasture. It is possible however to make extensive use of the sheep to pasture off brush and at the same time bring them through the season in good form. This can be done when the farm is sufficiently well developed to devote some of the cleared land to sheep pasture. The sheep may then be kept on the brush in the spring into July, at which period the foliage is fresh, and browsing does the most effective

Land, Sheep Pasture well broused.

work. After the middle of July the brush is dry and unpalatable, browsing does not kill it as well, and the sheep will rapidly run down. It is then that they should be turned upon other pasture. In the early spring a little grass or rye pasture will also be of great help. Such a rotation of pasture requires fencing, and this will often deter the farmer from adapting it. But it should be held as a goal to work for, if sheep are to be a permanent addition to the farm.

Success with sheep depends upon the lambs. The old sheep may thrive, apparently, but if the lambs are weak and die the flock soon melts away. The strength of the lambs depends more than all else, on the care and management of the flock through the winter. A common mistake, and one always attended with fatal consequences to the lambs, is to keep the sheep too warm. No amount of cold will hurt a sheep with its thick coat of wool, but crowding into a close shed overheats and sweats them, so that they take cold when turned out. Sheep should be protected in the winter

not from cold, but from snow and wind, especially drafts. The doors of the sheep shed should be large and on the south side. They should always be open, even in the coldest weather. The best door is one of two sections, the lower of which can be closed to keep the sheep in when necessary, while the upper is left open. The sheep should be out doors all the time at will except in storms, and at least one feed a day should be given them at some distance from their shed, to make them take exercise in going and coming. During the winter of '98 and '99 the sheep, which had been bought quite late in the fall were wintered over in a shed too small for them, without proper doors. The effect of the crowding and overheating became evident in the spring, when out of fifty lambs, only six were strong enough to live, in spite of the utmost care during lambing. Since that time, with the same ewes and a proper shed and handling, the lambs have been strong and healthy. Sheep can be wintered over on wild hay and cornfodder, but here again, best results cannot be expected. Clover hay is nearly a perfect feed. But where oats or bran can be fed towards spring it will improve the tone of the flock at lambing time. The sheep should not be bred before December 1st, unless one wishes early March lambs and has the additional experience and equipment necessary for success. May is the most favorable month for lambing. While during the summer sheep require the least attention of any class of stock, they make up for it in lambing season. At this time the flock should be under constant watch. If the weather is cold or wet, young lambs unless found at once will never get up, but die of chill and exposure. If the lamb is weak when found, it may often be gotten on its feet by holding the ewe and allowing it to suck, or even feeding it from a bottle. Promptness in rendering this aid to the lamb is the important point. Delay so draws on the vitality of the lamb that it can not often be saved. No amount of care will avail a constitutionally weak lamb unless it is raised on a bottle as a pet, which method has its limitations. But strong vigorous lambs if born under unfavorable circumstances will need these attentions, and here is where the care pays. A strong lamb born in the sunshine seldom needs attention. The ewe and young lamb should be at

once separated from the flock and placed by themselves in a small pen for a day or two. Young ewes will otherwise often desert their lambs, and it is seldom that a ewe can be made to adopt another's lamb unless it is done at once after the loss of the lamb at birth. They should be kept in a yard or grass plot for at least a week, until the lamb is strong enough to run with the flock. While sheep will live on the water they get in the dew on the grass and succulence of the herbage, and by eating snow, pure water, both in summer and winter is essential to their thrift. They should be free to choose their own time of pasturing. In the summer this will be at early dawn, and at dusk. It will not pay beginners to start with full blooded ewes, as much must be learned the first year or two and the experience might be costly. On the other hand, Merinos, though they pick a better living from the brush, are too small and take too long to improve for best results from the standpoint of mutton or quantity of wool. Grades of the large breeds should be secured if possible and bred to a full blooded buck. The flock on the farm was originally grade Merinos and though bred to an Oxford every year for three seasons, the type does not yet show the improvement that could have been obtained in the first cross with grades of a larger and better class. It is a mistake to use a grade buck if a full blooded can be obtained, as the improvement will be less pronounced or altogether wanting, the animal usually lacking prepotency, or the power of getting off-spring similar to himself. Wolves have never bothered the flock. They may easily become a serious menace and necessitate careful corralling at night, in sections where they are abundant. Bells placed on the ewes are a protection.

Summer Pasture Crops for Sheep.—Of the crops raised as a supplementary pasture for sheep, cornfodder has proved most useful. For this purpose it is sown thick, in drills, and is pastured when it stands about 3 feet high. It furnishes pasture in August, on which the sheep thrive. Sown June 1st, it reaches the desired height during the latter part of July. For late pasture it can be sown at any time up to July 10th. To illustrate the amount of pasture afforded by corn, a field of 3.6 acres in 1900 pastured 73 sheep for 31 days,

during August and early September. In 1902, cornfodder was sown in the furrow on breaking and furnished a large amount of pasture for the flock in August.

Rape is often mentioned as a supplementary sheep pasture. It has not done well on light or sandy soils on the farm. It requires a rich, heavy or black soil for good results and should be sown by July 15th at the latest. It resists frost and thus furnishes pasture after corn is frozen, and sheep relish it above all other crops. Early spring pasture is best furnished by winter rye, which may be pastured by May 10th. It is of great benefit in lambing season. Grain may be devoted to pasture and will furnish a large amount of feed as it can be eaten down two or three times if taken before the shoots appear. It is not often that grain will be devoted to this use. Second crop clover makes excellent late fall pasture after frost, and spring seeding if heavy and not pastured till very late, may be used in some instances. Grass makes good pasture for sheep at any season.

The farm, more for experiment work than as an example, has fenced a twenty acre field into five small fields each 9x70 rods. The sheep have access to each field from a lane running along one end of the piece. A five year rotation of corn, oats, clover, timothy, winter rye and rape or other forage crop, is grown on these fields. The sheep run upon brush, but whenever it is deemed best they are turned on one of these crops, according to the season. Ten rods of moveable fencing confines them to the portion of the field they can use, and the rest is harvested in due season.

Cattle.—The station has maintained a dairy herd but has lacked the means for experiments with feeds and milk production on an accurate, scientific basis.

The period of winter feeding is somewhat longer than in the southern portions of the state. Ordinary pasture is not worth much before the last week in May. In many localities the wild pasture is very abundant, and cattle do well on it. The production of feed for wintering the stock will determine the number that can be kept. Where wild hay is available it is an important element in solving the problem at the outset. As the farm is cleared, more tame forage can be raised, especially cornfodder and clover. Whether dairy cows are to

be kept, or a type more suited to beef production, must be determined by the market. All dairy products command a good price which helps to offset the cost of feed. Where hay can be marketed at from $10.00 to $12.00 per ton there is often more money in it than to feed it to stock, The settler can best determine for himself how much and what class of cattle it will pay him to raise.

Hogs.—Swine raising on a large scale is not apt to prove profitable, except where some local condition provides a source of feed, as in the vicinity of large towns. It will always pay to have pigs to eat the slops and waste from the house. Lumber camps raise good pork by letting the pigs run wild in the summer and feeding in the winter from the camp. Barley makes the best feed to raise for pigs, as corn is uncertain. Probably the best plan is to raise spring litters, provide range for them during the summer and finish off as soon as possible in the fall and early winter, carrying over only the brood sows.

Garden Vegetables.—Garden vegetables prefer a light sandy soil well manured. The excellent growth of vegetables

Garden and Field looking east from Barn.

is often taken as an index of the agricultural possibilities of a region. Vegetables depend for their quality not necessarily on the strength of the soil but on its quickness, warmth, and fertilization with manure. The production of grain, grass and other staple crops is a better standard of general merit than the size of a cabbage. The vegetable garden should always be manured no matter what soil it is on, as the results will be increased in proportion. Nearly every kind of vegetable has annually been raised at the farm and of very good quality and size. The season is short for watermelons and muskmelons and only the earliest varieties should be tried. Two varieties of watermelons which have ripened are Hungarian Honey and Fordhook. Tomatoes should also be started as early as possible in the spring, in the house in order to ripen a crop before frost. They should be set out about June 5th. Sweet corn will always mature for the table, even the later varieties.

Strawberries.—The strawberry crop in this country ripens from July 4th to 20th. This brings it on the market after the berries from other sections are exhausted and insures a good sale. Strawberry culture on the farm has been successful. Strawberries need fertility and the plants will soon deteriorate on poor soil not well enriched with manure. They also need, and must have plenty of moisture during the ripening of the crop. A rather low but drained spot should be chosen. The land should be plowed in the fall, rather deeply. Manure can be plowed in at that time, but it is better to spread it, if fine, on the plowed surface and work it in with a disc harrow if possible. It is better still to make both applications.

In this section as well as elsewhere the plants should be set in the spring, not the fall, and allowed one season to grow before bearing a crop. If set one and one half feet apart in rows four to four and one half feet apart and cultivated one way, they are the least trouble. The runners are not clipped but form a matted row. A covering of 2 to 3 inches of straw is spread late in the fall after the ground is frozen and is left on the plants in the spring as long as possible to delay them till danger of frost is past. This straw must then be raked off the plants but left between the rows,

to keep down the weeds and retain the moisture in the soil for the crop. The bed should seldom be left to bear more than two years as it is so much easier to set out a new bed and plans should be made to do so each year. Strawberries differ in their adaptability to our conditions and some varieties do not do well. Of many kinds tested, the Brandwine, Clyde, Splendid, Lovett and Bederwood, have given best results. All are staminate or perfect varieties and may be planted alone. Haverland and Warfield are good but need one of the above kinds in alternate rows with them for pollenation.

Raspberries.—It is not safe to grow any kinds of raspberries here without winter protection, but if this is given, most of the better varieties may be successfully raised. This simply means keeping them trimmed out in hills by cutting off all but a few suckers each summer, then bending the bunch of vines over and throwing dirt on the tops and the stalks as far as possible. Straw may be thrown on but if snow is plentiful, it is not necessary. The kinds successfully raised on the farm are Turner, Marlboro and Loudon. Others have not been tried. Blackberries, treated similarly, will ripen a crop. In 1902 the Snyder, and Ancient Britain varieties yielded well. Currants need a rich preferably clay soil and will not thrive on sand. The climate is favorable.

Apples.—In planting trees it must be bone in mind that the northern counties of Minnesota are beyond the natural range of the apple. Success can only be won by careful choice of varieties and local conditions. A northeast slope, not too steep, is universally recommended for apples, as it gives protection in the summer from hot winds. But in this section the slope is not so important as the soil. Poor success will follow setting out trees on sandy soil with gravelly subsoil. The apple needs a clay subsoil at not too great a depth. To secure this, it would be better to take level land or a south slope if the soil on a north slope is not right. The presence of large bodies of water improves the local chances of success with apples, by holding off the first frost in the fall and delaying the spring thaws which cause sunscald. But unless the hardiest varieties are planted, failure is certain. It is a dangerous plan to buy trees of nurseries

located many hundreds of miles away, which have been necessarily grown under the different conditions, and in most cases, will be of varieties that will not live in this climate. Local nurserymen, who have been struggling with this problem of hardiness for years, are more apt to offer only the best varieties. The tests on the experiment farm have not been made under the best soil conditions, and growth has not been vigorous.

Some idea is being obtained of the relative hardiness of the varieties. Of the apples, Hibernal, Pattens Greening and Duchess in favored localities, are recommended for trial. Of crabs, Martha is perfectly hardy. Virginia and Transcendent should be tried. If other kinds are planted, they should be only those advertised as extra hardy. In this section apples should always be set out in the spring.

Plums.—The varieties of American or native plums are nearly all perfectly hardy here and will grow upon sandy soil as well as clay. They will succeed therefore in many places where apples will fail. To obtain a crop several kinds must be set out near each other. Some plums ripen too late, and the varieties marked early should be chosen for planting. The orchard on the farm, set out in 1899, bore in 1902 a very good crop of plums. The best plum tested was the Cheney both in earliness and size. It will ripen in any sea son. The Aitkin is not a vigorous tree nor a good bearer, but as it blossoms at the same time as the Cheney it is recommended for planting with it for the pollenation of the flowers. New Ulm and Wolff, both do well on poor soil and ripen in an ordinary season. Weaver ripens but was small. It will probably do well on good soil. DeSoto, Rollingstone and Surprise are too late in ripening to be safe here. It is recommended that a wide use be made of these plums, as the chances of failure are very small.

Reforestation.—In order to investigate the cost and practibility of re-stocking the land with pine, which is too hilly, rocky or sandy for agriculture, a number of acres were laid off on the west half of the northeast quarter section and planted in 1900 to white and Norway pine. The trees used had been furnished by the Bureau of Forestry in '98 and had grown two years in nursery rows. When transplanted they were a foot to eighteen inches high. This was too large. They should have been moved a year earlier. The growth was retarded a year by the transplanting and the cost was probably 30 to 40 per cent greater than for trees a year younger. The cost of digging, transporting one-half mile in wagons, and planting, was a little less than one-half cent for each tree. The trees were set at equal distances each way. The cost per acre depended on the distance apart they were

set. At four feet, 2722 trees were required, and the cost was $11.20. At six feet intervals, it took 1210 trees, costing $5.60. Eight feet apart required 681 trees, and cost $3.14, while at 10 feet, 435 trees were used, at a cost of about $2.50. The greater interval adding somewhat to the proportional cost of planting. To transplant evergreens it is absolutely necessary to keep the roots from a moments exposure to the sun. In this case they were dug but the roots kept covered with dirt till moved. They were then put upright in a wagon box and drenched. From this they were taken in baskets and handed one at a time to the planters, who set them out at once. No water is required, and it is even injurious to water evergreens after they are set out. The ground should be moist when planted. These trees were set by cutting the surface on three sides and turning it back, taking out a spadeful of dirt, inserting the plant, tramping the loose spadeful on the roots and turning back the sod next the stem, stamping into place. In spite of the prolonged drought of 1900, nearly 95 per cent of the trees have lived and are now making rapid growth. A fire lane has been cleared and plowed on the west side. In all 12½ acres were planted, each acre representing a type of planting. Four acres are pure white pine at 4, 6, 8 and 10 feet intervals. Each is duplicated with Norway pine. One acre bears mixed white and Norway pine, and on one, jack pine was planted alternately with white and Norway. Norway and Scotch pine occupy an acre, in mixture, to test the relative merits of the two species. It is hoped that the experience and information thus gained may serve as a guide for similar work wherever conducted.

Ornamental Shrubs.—Of the many kinds of shrubs planted on the farm, some have proved perfectly hardy and of value for ornamental planting. They are as follows:

Lilac.—Tartarian Honeysuckle, a bush resembling lilac in habit, bearing small pink flowers in the spring.

Caragana, or Russian pea tree, a bush with pinnate leaves, bearing small yellow flowers.

Buckthorn, a small thorny shrub.

Buffalo Berry, a shrub, bearing grayish green leaves and tart red berries resembling currants. These are borne profusely and make excellent jelly.

These shrubs all make good hedge plants, and all but buckthorn are equally ornamental set out as individuals. Of native shrubs, the highbush cranberry and dwarf maple are useful and the kinnikinnick or red dogwood. Spireas, hydrangias and Russian olive have not always escaped injury in winter. The roots of clematis come through in good condition.

SYNOPSIS.

Practical bearing of the disease upon the live stock interests of Minnesota. Conclusion, a serious problem.

Cause, a rod-shaped germ very closely resembling and possibly identical with the swine plague bacillus. Method of dissemination and infection unknown.

The disease may appear suddenly and cases develop rapidly, or the cases may be chonic and develop slowly, there being several widely differing types of the disease.

Ante-mortem symptoms are frequently unsatisfactory in the acute cases, because of the very limited period of sickness before death. Chronic cases on the other hand give much more satisfactory opportunities for studying symptoms.

Symptoms discussed. Disease easily recognized as a rule on examination post-mortem.

It has been less than three years since the first case in Minnesota was recognized by Dr. Wilson. During the following two years there were reported 80 outbreaks, involving 52 farms, and a loss of 551 cattle. There were probably many other outbreaks which were not reported.

Records of outbreaks which came under the personal observation of the writer, including a series of examinations post-mortem, with histories of the ante-mortem development.

Information concerning the disease put on permanent record.

University experimental outbreak described in detail; the cases uniformly of an acute meningeal type and closely resembling specific cerebro-spinal meningitis.

Case of hæmorrhagic septicæmia in a sheep. The first case of this disease which appeared on the University Farm died very suddenly. The nature of the disease not suspected until examination post-mortem had been conducted.

Possible relation of hæmorrhagic septicæmia (meningeal type) to some cases of supposed milk fever.

A number of outbreaks of suspected hæmorrhagic sep-

ticæmia which did not come under the observation of the writer are recorded.

Table offering a comparative study of hæmorrhagic septicæmia, anthrax, symptomatic anthrax, and cerebro-spinal meningitis, with a view to distinguishing between these several diseases.

Diagnosis of hæmorrhagic septicæmia, and differential diagnosis between the diseases compared in the table, discussed.

GENERAL CONCLUSION.

Hæmorrhagic septicæmia, a general term which covers a number of varying types of a disease affecting various species of animals, but all probably due to a specific microbe, *Bacillus boriseptícus*. Not a new disease, outbreaks having been described under various names and in various countries since 1858.

GLOSSARY.

The following glossary is inserted for the benefit of readers who are not familiar with the technical terms used. It is very difficult to discuss a technical medical subject without using some scientific terms. Such terms have been avoided as far as possible in this bulletin:

Anterior—front.

Auscultation—examination by ear.

Bronchial—pertaining to bronchial tubes of the lungs.

Cervical—neck.

Costal—pertaining to the ribs.

Duodenum—first portion of small intestine.

Dura mater—one of the membranes surrounding the brain and spinal cord.

Emphysema—containing gas.

Endocardium—inside lining of heart cavities.

Hæmorrhage—appearance of blood outside normal channels.

Hepatized—liver-like, solid.

Ileum—portion of small intestine following the duodenum.

Mediastinal—pertaining to membranes which separate the two lungs.

Meningitis—inflammation of membranes surrounding the brain and spinal cord.

Mucous membrane—membrane lining cavities that connect with surface of body.

Parturient paresis—milk fever of cows.

Petechia—small reddish or purple spot, bloodstained.

Pericardium—sac around the heart.

Pleura—membrane that covers lungs and lines chest.

Posterior—rear.

Pylorus—outlet of stomach.

Septicæmia—included in the common term 'blood poisoning.'

Serum—watery portion of the blood.

Tympanitis—bloating.

HÆMORRHAGIC SEPTICÆMIA.

Whether it is proper to speak of this as a disease or as a collection of diseases due to identical or similar germs may possibly be questioned, but for the present at least, and until we have more light on the subject, we may speak of it all as hæmorrhagic septicæmia. This disease is very interesting on account of several peculiarities. It is interesting because of its protean forms; it is serious because medical treatment so far as we know is absolutely useless and hopeless. We are utterly helpless in the matter of prevention because we have practically no information as to the method of infection or method of spread. Those who have had a chance to study the various outbreaks in Minnesota have been quite unable to trace any connection between one outbreak and another, or to trace a previous history for any given outbreak. It is proving interesting and important to those members of the veterinary profession who have been so fortunate or unfortunate as to come into contact with it, because of the extreme difficulty of making antemortem diagnoses. In some outbreaks that have been carefully studied, antemortem diagnosis for the first case at least was apparently impossible; but on the other hand there have always been plenty of opportunities for examinations post-mortem, and here the evidence is usually clear.

There is a very practical side to this disease, especially when considered from the farmer's standpoint. It appears suddenly and under all sorts of conditions; a number of animals, usually a large proportion, die, and the disease disappears as suddenly as it came. The owner has lost a certain amount of property, in live stock, without a trace of information as to whence the disease came or how soon the visit may be repeated. The owner would be especially interested in knowing the method of infection and the possible agencies through which his herd may receive a re-infection. If hæmorrhagic septicæmia, like glanders, comes by a specially introduced infection, then he has a certain proposition to

face. If on the other hand the microorganism of hæmorrhagic septicæmia, which resembles in all laboratory peculiarities the germs of swine plague, are commonly present in less virulent forms or present under conditions where there is but limited opportunity for the development and the production of disease, then the farmer may expect an outbreak of it at any time and so far as he knows under any conditions, and he has no means of guarding against it—a quite different proposition.

Cause.—The specific cause of this disease is apparently a germ (*Bacillus bovisepticus*) which cannot be distinguished from the bacillus of swine plague by any cultural or morphological characteristics. How this micro-organism spreads or how it gains entrance into the animal body is not known, but at present we suppose that the entrance may be effected by inoculation; through the respiratory or through the alimentary mucous membrane.

History and Development.—The onset is usually sudden and most unexpected, and yet in some recent outbreaks of disease in which the presence of the micro-organism was demonstrated, the onset was quite slow and the cases were distinctly chronic. Hæmorrhagic septicæmia is probably more prevalent than is generally supposed, and it is undoubtedly true that a great many outbreaks of this disease have been incorrectly diagnosed as anthrax, symtomatic anthrax, infectious cerebro spinal meningitis, corn stalk disease, and very possibly as parturient paresis. From reports that have appeared in the veterinary journals at various times it is very evident to those who have had opportunity to study this disease, that outbreaks of hæmorrhagic septicæmia have appeared in a great many different sections of the United States at least, and have been incorrectly diagnosed. Cases which have been described in the East as cerebro spinal meningitis have been very plainly hæmorrhagic septicæmia, and this is also true of so-called corn stalk disease of the West.

Season and climatic conditions apparently have nothing to do with the prevalence, virulence or disappearance of this disease. The mortality of the past few years during which it has been studied in Minnesota has been extremely high, cases all ending abruptly in death, with the exception of cer-

tain outbreaks where the cases were chronic. These tended to disturb our supposed information concerning the disease, particularly in reference to its rapid and invariable fatality.

More recently an outbreak appeared under the observation of the writer where all cases gave uniformly clear antemortem symptoms of cerebro-spinal meningitis, and yet examinations post mortem revealed in addition to the expected lesions of cerebro-spinal meningitis, the characteristic hæmorrhages of hæmorrhagic septicæmia, and the organism which is supposed to be the specific cause of the disease was demonstrated beyond reasonable question. (See Minnesota Experiment Farm outbreak, provisional report by Dr. Westbrook.) In this outbreak as in all the earlier ones, the mortality was very high, nine animals sickened and nine died.

Symptoms.—The writer has had the privilege of studying closely the development and full history of seventeen cases. The temperatures were uniformly normal or subnormal, except in two cases where the temperature rose rapidly just before death. There was nothing in the nervous disturbances that was especially diagnostic, except that in several cases the skin has been hyper-sensitive. The subjects have usually been disinclined to move about apparently because movement caused pain. In an outbreak which occurred at the University Experiment Farm, and which came under the writer's daily observation, the prominent symptoms in all cases were those of cerebro-spinal meningitis, but it would be very misleading to suggest that these nervous disturbances are characteristic of hæmorrhagic septicæmia. Local lesions which correspond to the tumors of anthrax and symtomatic anthrax are very limited or wanting. The urine in many cases has been scanty or blood stained, and this is also true of the bowel discharges. The examinations post-morten are very much more definite and satisfactory. The blood is apparently normal. Subcutaneous hæmorrhages are common and vary greatly in size and intensity; in some cases they are large and the hæmorrhagic condition is marked. In other cases the hæmorrhages are punctiform, scattered, and few in number. The hæmorrhages may appear almost anywhere in the subcutaneous tissues or involve any of the viscera. The spleen is not enlarged, but there may be

hæmorrhages on the surface. The hæmorrhages usually have very sharply defined borders and are easily recognized as hæmorrhages. The serous membranes frequently show small haæmorrhagic areas, and the heart, especially the auricles, are often intensely hæmorrhagic.

We may summarize the symptoms as follows: As a rule the disease appears suddenly; the case develops very rapidly and terminates fatally. The antemortem symptoms are very unsatisfactory from a diagnostic standpoint. The postmortem symptoms are definite and as a rule easily recognized and consist of more or less extensive hæmorrhages which are sharply defined when they appear upon the surfaces of the vicera and serous membranes.

History of the Disease in Minnesota.—It is now about two years since this disease was recognized in Minnesota by Dr. Wilson, of our State Board of Health Bacteriological Laboratory. During these two years there have been reported to the State Board of Health, 80 outbreaks among Minnesota cattle; these outbreaks involved 52 different farms, appeared in 18 different counties, and resulted in a loss of 551 cattle.

It is safe to assume that a considerable number of other outbreaks appeared but were not reported.

Four outbreaks have come under the writer's personal observation and in three of these the opportunity was unusually good for careful study of the cases from a clinical standpoint.

OUTBREAKS WHICH CAME UNDER DIRECT OBSERVATION.

JOHNSON OUTBREAK.

Dr. Wilson and the writer went to North Branch, Chisago County, October 30th, for the purpose of investigating a very virulent disease that had appeared in a certain herd. The previous history was rather unsatisfactory because indefinite and incomplete. It was learned that five calves belonging to another party had died in a certain pasture earlier in the season, probably in June or July. The history of these cases agreed with the recent cases which we went to investigate, in that the calves had died suddenly; there had been some slight local, diffused swellings and on skinning, dark red areas were noticed by the owner. Another neighbor had lost suddenly a cow some months before with symptoms and history that agreed closely with those of the present outbreak and the five calves previously mentioned.

Mr. Johnson reported that he had 20 cattle in his herd when the disease first appeared on September 15. A portion of the pasture was dry; another portion quite low and wet, but without timber. None of the cattle had had access to standing corn stalks. He had lost two animals about November 1, 1899, from what he supposed was the same disease. These were calves about six months of age. The owner noticed that in these previous cases the manure was coated with blood or showed bloody streaks. During 1900 one was taken sick and died suddenly in July, another about the middle of October. He had lost also one roan steer calf, seven months old, which died sometime early Monday morning, October 29th, and a red heifer calf about the same age, which died on the same Monday. Both deaths occurred suddenly. The former was noticed to limp some in walking, the trouble being apparently in the left front limb. These two calves were examined post-mortem by Dr. Wilson and the writer on Wednesday, October 31st.

The following parts were examined and all parts were

normal except as noted. *Parts examined:* Subcutaneous tissues; mucous membranes; heart; lungs pleuræ; alimentary tract; bladder; post pharyngeal, mediastinal, bronchial, mesenteric, portal and inguinal lymphatic glands, kidneys, and spinal cord in the anterior cervical region.

Autopsy.—1. A red steer calf in fair condition and about four months of age, had died about 36 hours prior to our visit. The carcass was moderately bloated, otherwise in fair condition for examination. The skin was discolored in places, especially where denuded of hair. The subcutaneous areolar tissues were emphysematous with fairly well defined hæmorrhages, especially marked at the throat and adjacent portions of the inferior cervical region. The superficial muscles beneath these infiltrated areas were similarly involved. The surfaces of the limbs below the knees, and hocks, did not show hæmorrhages as in the cases previously reported by Drs. Wilson and Brimhall. There were no wounds of the skin near the feet that could be detected. Tracheal, oesophageal, and laryngeal mucous membranes show marked inflammation, being dark, swollen and wet.

The kidneys were probably normal at the time of death but when examined they were soft and showed numerous light yellowish areas about 8 mm. in diameter. The lungs showed a few small, sharply defined hepatized areas, markedly resembling the peculiar lesions of swine plague. The owner had noticed that this calf was quite lame, while sick, and it is interesting to note that in the examination one of the peculiar areas of hæmorrhagic septicæmia was found involving the shoulder muscles. Several articulations showed ulcerations of the articular cartilages, especially the humero-radial and tibio-tarsal. See Fig. 1. These ulcerations were about 31 mm. long by 12 mm. wide.

Autopsy.—2. This was a red heifer calf, 7 or 8 months of age, in fair condition. The animal had been dead about 48 hours but showed less post-mortem change than No. 1. So far as superficial parts are concerned the post-mortem findings of No. 1 will apply very closely. This is also true of the lymphatic glands, mucous membrances and kidneys. The dura mater in the anterior cervical region had evidently been the seat of a very active inflammation. The lungs

showed the peculiar hepatized areas of swine plague closely resembling those found in No. 1.

THE CAFFREY OUTBREAK.

The second outbreak studied by the writer in part with Dr. Wilson, occurred near Cokato. My first information came in the following letter:

Nov. 26, 1900.

"Dr. M. H. Reynolds,
St. Anthony Park, Minn.

Dear Doctor:—Mr. C. living two miles north, lost two cows about three days ago and a third one is nearly dead now.

The first cow was apparently well at night, and was found dead in the morning. The next day another cow was taken sick and I was called. The second cow was comatose, unable to rise, and died in about twenty-four hours.

Symptoms:—This cow was lying on her breast with the head turned to one side as in parturient paresis. She was comatose, her respiration stertorous; temperature 101; pulse could not be taken.

Post mortem:—There was cherry-wine colored serum in the abdominal cavity; the small intestines were very badly inflamed; the liver was slightly swollen, dark and easily torn; the spleen was normal in size and a little darker in color than normal. The cephalic lobes of the lungs were inflamed, the heart had a parboiled appearance, and everything indicated a generalized septicæmia. Both lungs were congested.

These cattle were fed on corn stalks, hay and shorts.

Yours respectfully,
H. A. HELA, M. D. C."

In company with Dr. Wilson the writer reached Mr. Caffrey's place on Nov. 29th. We learned that the Caffrey cattle had been kept in pasture as long as the grass was good, and were stabled at night. Later in the season they had been fed on wild hay, corn stalks and shorts, the feed being apparently all fresh and good. The pasture in which the cattle had been during the summer and fall contained both high and low ground with some timber and brush. The owner had noticed in those cases which had died before we reached the place, that the head had been drawn far back in some instances, and in others the head was held in the flank as in parturient paresis, these positions being assumed shortly before death. He had noticed no superficial swellings, but said that the animals seemed to have irregular chills. He had also found blood stained areas in all cases on the surfaces of the bodies after skinning. The sick animals

had shown complete loss of appetite from the time they were first noticed ill. There had been no swine disease or chicken cholera in the neighborhood during the past season.

The following deaths, 1 to 6 inclusive, were reported to us by the owner:

Death 1.—A six-year old cow in fair condition had appeared normal in all respects on the evening of Nov. 22, and was found dead the next morning, the owner not having supposed that the cow was sick. The cow had died in an easy natural position, as though resting. Evidently there had been no struggle.

Death 2.—Another six-year old cow was found down early in the morning (7 o'clock) on Nov. 22. She was unable to rise, held the head in the flank and died on the evening of the 23rd. There was persistent constipation. No surface swellings or tumors.

Death 3.—A spring steer calf, in good condition, was first noticed sick on the evening of Nov. 25. This animal tried repeatedly to rise and failed. Died about 10 a.m., November 26th. Constipation persistent.

Death 4.—This was a four months old calf. The owner heard a noise in the stable about 2:00 a.m. on Nov. 27th. He went out to investigate and found the calf jumping into the manger and shoving the head against the wall. This calf died at 11:00 a.m. with the head drawn far back.

Death 5.—This was a spring calf, supposed to be in perfect health until the morning of Nov. 27, when it was found almost dead. The animal died a little later. Constipation persistent.

Death 6.—An 8-year old black cow, in good condition, was first noticed sick Nov. 28th at 7:00 a.m., and found dead about 10:30 a.m. She dropped suddenly at 7:30, and subsequently tried repeatedly to rise but could not. She lay on the left side with the head in the flank much of the time. Later the cow succeeded in getting on her feet, but fell suddenly with the posterior limbs spread outward and backward, the body dropping suddenly from a standing position to the ground. Later the cow drew up her limbs and lay over on one side in a rather natural position with the head swung. She struggled considerably but later died easily and slowly.

Autopsy.—The tissue lesions were rather severe. Both *lungs* showed considerable interlobular emphysema, which was especially marked in the ventral lobes. Petechial spots were especially marked on caudal lobes. Right caudal lymphatic gland was dark, swollen and showing petechiæ.

The *diaphragm* showed scattering petechiæ on peritoneal surface of tendon. The *heart* was markedly hæmorrhagic, the hæmorrhages being both superficial and deep.

The gall bladder was filled with a dark bloody fluid. Its walls were infiltrated and œdematous and the surrounding tissues were œdematous.

There were petechiæ on the third stomach penetrating the walls. Eighteen inches below the pylorus, the duodenum was œdematous and bedded in a yellowish gelatinous mass. The small intestines showed well marked petechiæ throughout. See Fig.'s 2 and 3. These areas were large and abundant.

There were petechiæ in the kidney substance and upon the surfaces. The bladder walls were hæmorrhagic, the mucous membrane being very much inflamed, thickened and softened. There was a small quantity of bloody fluid in the bladder. Spleen petechiæ were abundant and especially conspicuous on the inferior extremity.

Death 7.—This was a black and white heifer in fair condition, seven months old. (See Fig. 4). This animal was first seen by Drs. Wilson and Reynolds at 2:00 p. m. November 29th. The temperature was then 98.6, the calf being out door on a very chilly day. The respirations were very shallow but normal in frequency. The pulse was not taken. This calf stood with the back arched, shivering and apparently ready to fall at any minute. The hair was rough; there was a slight filling at the inferior cervical region, and the eyes were sunken. The muzzle was dry.

At 4:45 p. m. the calf was still out of doors, temperature 100.9; pulse 72 full, soft and fairly strong; respiration 20. The heart and lung sounds were normal so far as could be determined by auscultation. At 7:30 p. m. the temperature was 101.1, respiration, pulse, etc. about as at 4:45. The calf was now put in the stable out of the wind, but the stable was cold.

At 10:00 p. m. she was lying on the left side with the head resting forward on the ground. The pulse was 54 and much weaker; temperature 99.9, respiration slightly irregular and somewhat jerky. The skin and underlying tissues over the body seemed very sensitive under pressure. This was especially noticable over the abdomen. The calf had evidently failed rapidly since 7:00 p. m. The head was jerking spasmodically and unconsciously, the spasms affecting especially the cervical muscles. The pupils were dilated, muzzle dry and the neck seemed to be filling slightly at the throat.

At 3:30 a. m. the calf was dead, lying flat on the side in a rather natural and easy position. There were noted slight rigor mortis, moderate tympanitis and somewhat blood stained feces. The animal had died as nearly as could be estimated about 2 a. m. The respiration had been slightly stertorous from 7:30 p. m. to 10:00 p. m., after which the animal was not seen until found dead.

Autopsy 4.—There was considerable serum in the abdominal cavity and a small quantity in the pleural cavity. Both lungs were somewhat congested but showed no petechiæ. The trachea contained an abundance of frothy material and the bronchi were moderately injected. The esophageal mucous membrane was normal. The diaphragm had few small petechiæ on the pleural side. The liver showed a few small hæmorrhages on the spigelian lobe. There were a few moderate hæmorrhages on the heart surface and on the endocardium. The duodenum was in a condition very similar to that described in the postmortem record of death No. 6. It was involved in a gelatinous mass filled with yellow serum about ten inches from the pyloris. The ileum was injected and the mucous coat showed areas of distinct inflammation. The rectal mucous membrane was very much inflamed. Subcutaneous hæmorrhages were present, but small and not well marked. None were noticed on the inferior cervical region or on the lower portion of the limbs. The plainest and most typical hæmorrhages were on the liver, as already noted. Both the parietal peritoneum and parietal pleura showed very little that was abnormal.

There was an old wound in the abdominal wall extend-

ing into the rumen about one inch in diameter. This injury must have occurred at more than a month prior to this examination. The stomach was adherent around the border of the abdominal wound and the abdominal cavity was shut off.

The left humero-radial articulation showed one ulcer involving the articular cartilage about 25 mm. long, oval in shape. The left tarsal articulation showed an oval ulcer about 38 mm. long. The other articulations appeared normal.

Post pharyngeal glands were enlarged, dark and markedly hæmorrhagic. The dura matter was moderately congested with a little serum in the canal at the atlo-axoid articulation. The bladder was normal and very much distended with normal looking urine.

The tissue lesions in this case were neither extensive nor severe, evidently a case of toxine poisoning.

Death 8.—A red heifer about 18 months old and in good condition, was first noticed sick Nov. 30th, at 7:00 a. m. She had previously been in good health so far as known. When first noticed she was bellowing occcasionally and standing apart from the other cattle. She refused her morning feed and was put in the stable about half an hour later. This calf soon went down and did not rise.

At 7:30 the temperature was 99, respiration 22, pulse 14 and good. Respirations were full but somewhat stertorous. The horns were cold. Evidently the circulation was poor. Light colored feces were passed.

At 10:30 a. m. the temperature was 97.8, having fallen 1.2 degrees during the previous three hours. Respirations were now 24 and markedly stertorous. Pulse could not be counted. The subject was failing rapidly. This case also showed the hyperensitive condition of the skin.

At 12 m. the temperature was 97.8, pulse was feeble and could not be counted. The respirations were still stertorous, the expiration being accompanied by spasmodic jerking of the abdominal muscles.

At 2:30 p. m. the temperature was 97, respiration about 24, and the heifer was lying stretched on the side.

At 4:00 p. m. the temperature was 96, respirations 24;

pulse could not be counted. The heifer was groaning with each expiration. The head was very much drawn back and the body still sensitive under pressure. The animal died at 10:30 p. m.

Autopsy.—A hasty postmortem by the owner discovered what he described as bruised areas under the skin.

Death 9.—A spotted heifer, 3-year old, was noticed sick on Dec. 2, at 4:00 p.m. She died about 5:00 p. m., having apparently been in the best of health until shortly before she fell dead. No hæmorrhagic areas under the skin were noticed by the owner.

BEDOR OUTBREAK.

The third outbreak which came under my observation occurred among the cattle belonging to Mr. John Bedor, living four and one-half miles east of St. Michael's Station. Mr. Bedor had lost one animal on Dec. 1st, and another on Dec. 5th, both dying very suddenly and unexpectedly. These cattle had not been in standing corn. The writer visited Mr. Bedor's place on Dec. 7th, and held examination postmortem.

Autopsy 5.—Bedor death No. 2. Parts examined: Subcutaneous tissues, trachea, œsophagus, dura and cord, post pharyngeal glands, thoracic cavity and contents, alimentary tract, spleen, liver and portal glands, pancreas, bladder, peritoneum, inguinal glands, humero-radial and carpal articulations. All parts normal except as noted.

There was a circular hæmorrhagic area involving the muscles just below the ischial tuberosity. The trachea contained a moderate quantity of frothy fluid. Post pharyngeal glands were dark and hæmorrhagic but normal in size. The pleura showed a small hæmorrhagic areas on the diaphragm and there were a few on the costal pleura. The lungs showed in one cephalic lobe, marked interlobular emphysema, similar to that described in autopsy No. 3 (Caffrey). And in the left caudal numerous hæmorrhagic areas. On the endocardium of the right ventricle of the heart, were several well marked hæmorrhages. Bronchial and mediastinal glands were not carefully examined, but were probably normal. There was one circular hæmorrhagic area on third stomach, quite typical. There were a few typical hæmorrhages, 5 to

10 mm. in diameter on capsule of liver. Duodenum and rectal mucous membranes were markedly inflamed and swollen.

Mr. Ralph Richner, a near neighbor to Mr. Bedor, reported that he had approximately 20 head of cattle in his herd November 20th. Mr. Richner lost nine, most of the animals dying very suddenly, and the entire nine within a few days after the first case, which appeared on Nov. 20th. His cattle had been fed shocked corn and other dry feed in the yard, and had not been in standing corn stalks at all. On skinning the animals and opening the carcasses, the owner had noticed that the livers and stomachs were spotted. The intestines were not especially noticed. He would probably not have noticed any petechiæ on the intestines, even had they been present. Dark bloody spots were noted under the skin in some cases.

UNIVERSITY EXPERIMENTAL FARM OUTBREAK.

History.—On June 6th, seven cows which had given a normal flow of milk in the morning, gave practically none in the evening. Otherwise the cows were apparently normal.

These cows were all noticed to be slightly ailing the next morning, with the exception of Dell 2. This cow was down and could not be gotten up. The others showed little except dullness. There was no rise of temperature; no evidence of pain or discomfort. When they attempted to walk, the gait was more or less irregular, resembling very much the gait of milk fever in its early stage. This became true of all cases sooner or later, and was of course more marked in some than in others.

There had been nothing new or unusual in the care or feed or other environments of these cattle except that for a few days and nights they had been kept in a pasture which had received some sewage overflow from our filter beds, by reason of recent rains. A salt box was located near the point where this overflow stood and the cattle unquestionably drank of this water. No other cattle had been in the pasture for ten days.

Symptoms, First Period.—The symptoms during the first 24 to 36 hours were not marked except as to continued

Fig. 1.—Ulcerations of Tibio-tarsal Articular Cartilage Tibia and os calcis. Johnson outbreak, post mortem number 1.

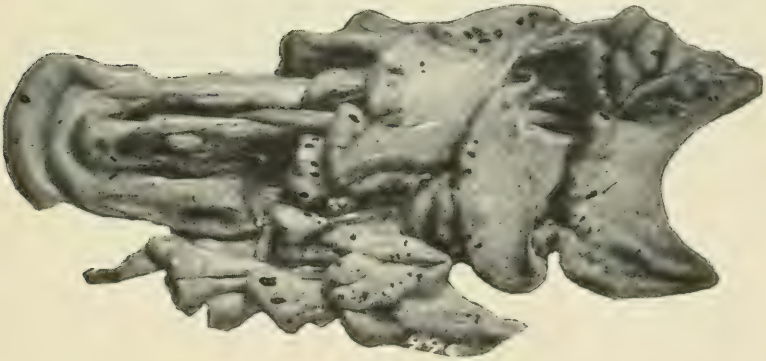


Fig. 2.—General View of Small Intestines. Caffrey outbreak, death No. 6. Showing many small, sharply defined hæmorrhages on peritoneal surface.

Fig. 3.—Section of Small Intestine. Caffrey outbreak, death No. 6, showing typical hæmorrhages on peritoneal surface.

Fig. 4.—Yearling Heifer. Caffrey outbreak; death No. 7; photograph taken thirteen hours before death.

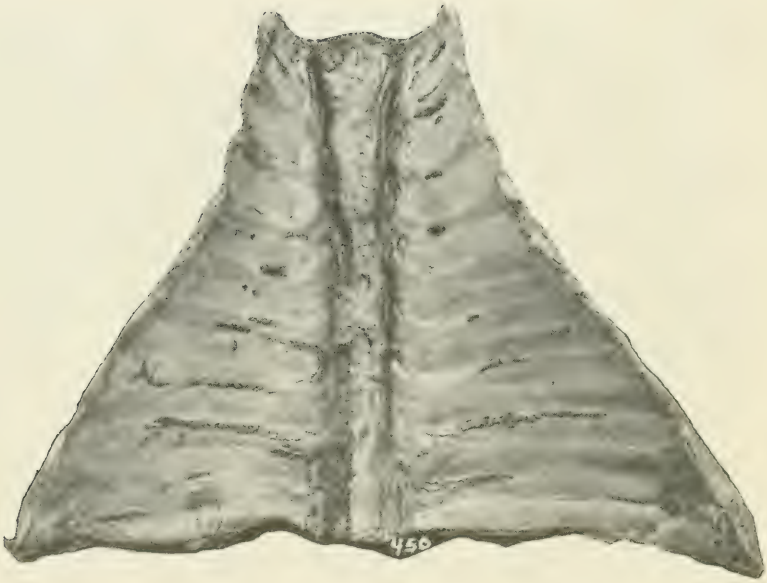


Fig. 5—Hæmorrages on Costal Pleura. Bedor outbreak, autopsy No. 5, death No. 2.

Fig. 6.—Hæmorrhages on Endocardium of Right Ventricle. Bedor outbreak, death No. 2.

Fig. 7.—Iris. University Farm outbreak. The cow stands in an apparently easy attitude, slightly stupid. A moment before she was drinking and switching flies unconcernedly. The photograph shows her condition at 5:00 p. m., at 6:15 p. m. she was dead.

Fig. 8.—Lou. University Farm outbreak, meningeal type; case in first stage, cow stupid.

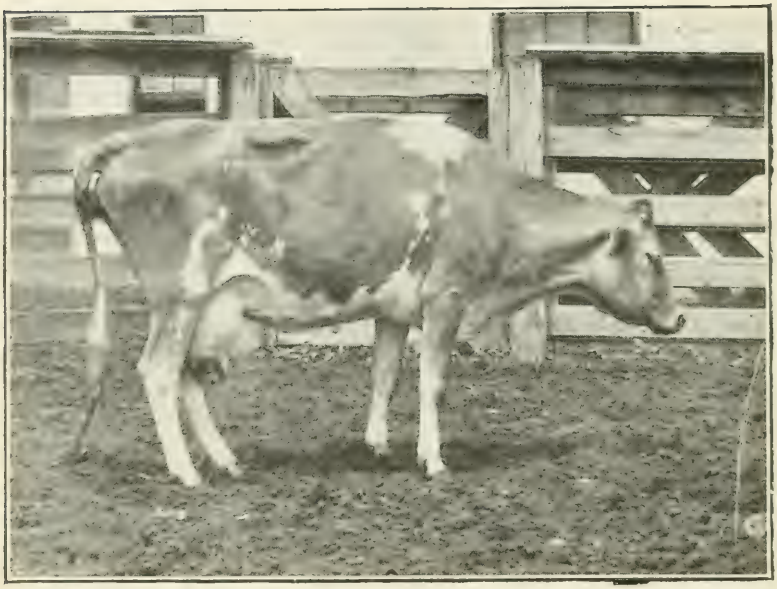


Fig. 9.—Dell. University Farm outbreak, meningeal type; case in first stage, stupid.

Fig. 10.—Dell. University Farm outbreak. This presents the same animal as figure 9, but in a slightly later stage of the disease.

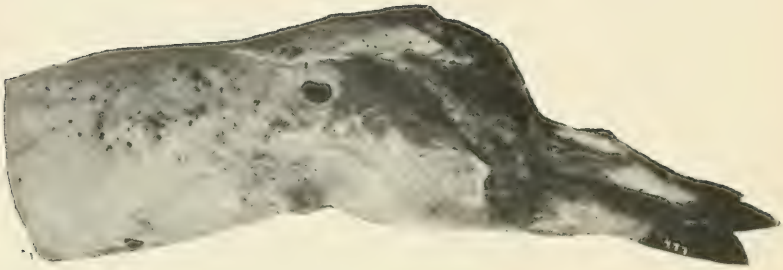


Fig. 11.—Swine Plague Hæmorrhages. These hæmorrhages involving the subcutaneous muscles resemble very closely the hæmorrhages of bovine hæmorrhagic septicæmia. It is interesting to note that the specific germ or germs of swine plague and hæmorrhagic septicæmia are not clearly distinguishable by any known laboratory procedure.

Fig. 12.—Hæmorrhagic Diaphragm. Pleural surface. Taken from a case of swine plague. The hæmorrhages are typical of those found in bovine hæmorrhagic septicæmia.

dullness, staggering gait and cold extremities. The skin was harsh and lacking sensation. This loss of skin sensation began at the posterior extremities and gradually extended forward. The milk flow was completely checked or practically so in all cases.

Second Period.—After 24 to 36 hours, diarrhea appeared, the discharge being dark and thin with very disagreeable odor. The breath in some cases was noticed to be very offensive. Nervous symptoms gradually developed and were very uniform in all cases.

The symptoms during the second period were those which belong to a gradually developing nervous disturbance and were very typical of cerebro-spinal meningitis. The inability to walk naturally was continued, the gait being irregular and weak. The neck was usually bent to one side and the muscles, particularly of the face and neck, were spasmodically contracted. During this period the animals, with the exception of Countess, a large Holstein cow, were still quiet, moving around very little; but the eyes showed a wild, unnatural expression. The skin continued to lose sensation progressively forward. Countess was continually groaning or rather grunting with each respiration; but not in evident pain. During this second period the animals commenced to chew in a nervous and very persistent manner, with more or less profuse flow of saliva.

It is also to be noted that the temperatures remained normal or subnormal during this period.

Third Period.—This was one of intense activity. The eyes continued to grow more wild and unnatural; the grinding of the jaws more active and more constant; the convulsions of the face and neck muscles became more intense and then gradually a period of intense restlessness and activity, and death ended the scene in every case.

Post Mortem Symptoms.—Several of these animals were examined and the symptoms as seen on examination post mortem were fairly uniform.

Meningitis involving the spinal cord or brain or both these organs was invariably present. In addition to this there were hæmorrhages involving the subcutaneous tissues, and lymphatic glands in various portions of the body;

also the pleuræ, pericardium, and surfaces of various internal organs, particularly the lungs and auricles of the heart.

Evidently we had here an undouted meningitis; not the specific form of the disease but one probably due to another germ. The lesions seen on post mortem are very suggestive of a hæmorrhagic septicæmia infection.

Diagnosis.—The veterinarians present, Drs. Lyford, Brimhall, Annand and Reynolds, agreed that the clinical symptoms and results of examinations post-mortem warranted a diagnosis of cerebro-spinal meningitis; but the hæmorrhagic conditions made it evident that we did not have the recognized specific type of the disease to deal with.

Source of Infection.—Owing to the fact that this particular outbreak occurred in a small portion of our herd and did not spread to other cattle on the farm, we were at first inclined to suspect the water in one of our pastures. The affected lot of cattle (our milking dairy cows) had been recently turned into this pasture and a certain small pond had been contaminated by sewage overflow from our filter bed, as already noted. But the fact that a few days later a virulent case of the same disease appeared in a heifer which had not, so far as known, had access to this water but had been kept in an adjoining pasture seemed to weaken this theory. In addition to this, the further fact that an experimental cow which was given this water only, for a period of about two weeks, gave her normal flow of milk and remained in perfect health, seems to disprove the sewage water theory as a source of infection. A careful survey of the history and surrounding conditions leaves us still in the dark except as to the following incident: A sheep died about a year before of typical hæmorrhagic septicæmia. It is possible that the infection came remotely from this sheep and that the meningitis was due to germ infection, the germ of hæmorrhagic septicæmia being the exciting cause. It should be shown in further explanation that the sheep in question was buried in a field remote, considerably more than a quarter of a mile from the pastures wherein the disease among cattle appeared, although drainage is from this field toward the pastures in question. Other cattle have been kept during the interval in these pastures without harm. We do not know where the

sheep received its infection. The cattle may have been infected from the same original source, or possibly there was an indirect infection from the dead sheep; but the latter theory seems very improbable. The sheep in question developed its disease and died in the sheep barn practically surrounded by other sheep, and yet we had no other cases among sheep at that time and none since.

PROVISIONAL REPORT ON BACTERIOLOGICAL EXAMINATION OF HÆMORRHAGIC SEPTICÆMIA AT STATE EXPERIMENT STATION, ST. ANTHONY PARK, JUNE 9th, 1902.

Specimens were collected from cows No.'s 1, 2, 3 on June 9th and from cow No. 4 on June 12th, at autopsies conducted by Drs. Reynolds and Brimhall. *Bacillus bovisepticus* (hæmorrhagic septicæmia) was obtained in pure culture from the liver and spleen of cow No. 4 and was found present also in the lung and meninges of cow No. 1 and in the pharyngeal gland and meninges of cow No. 2, though in these latter two animals the bacillus was mixed with other organisms such as colon bacillus. This was probably due to the fact that the autopsies were not made until several hours after death.

With the cultures obtained from the meninges of cow No. 1, rabbit No. 569 was inoculated intravenously, June 13th and died on June 14th (i. e. in less than 24 hours). From the rabbit the bacillus was obtained in pure culture from the heart's blood.

From cow No. 3 this bacillus was not isolated probably owing to the very great infection with other microorganisms which had developed after the death of the cow. Further rabbit inoculations will be made. In the meantime, from three of the sources, the microorganism has been obtained and one source, cow No. 1, the organism has been shown to be virulent. The strains of bacilli from the other two cows have been inoculated into animals but as yet no results have been obtained.

Your truly,

F. F. WESBROOK.

CASE NOTES.

Iris.—June 8, 3:00–5:00 p. m. She was slightly stupid, in standing position, apparently strong and breathing easily. This cow drank naturally and did not show anything unusual except a slight listlessness. Died at 6:15 p. m. Iris' death was very unexpected until within a few minutes before it occurred. See Fig. 7.

Vye Cow.—June 8, 11:00 a. m., quiet, apparently comfortable. Could walk fairly well, not supposed to be in any serious danger. This cow had a slight convulsion at 9 a. m.

1–3 p. m. quiet and lying in a comfortable position, died very suddenly.

June 9, the cow found dead early in the morning in a

back stable, having forced her way through an intervening door, which had been closed the night before. The cow had evidently shown great activity before death, although she was very quiet the evening before and not considered to be in immediate danger.

Lou.—June 8, 3–5 p. m., standing most of the time, walked fairly well but seemed very weak. Died about 6:15 p. m. See Fig. 8.

Sweet Clover.—June 8. Died about 9 p. m. after an hour or more of intense nervous and physical activity. She was champing jaws spasmodically and had convulsions of face and neck muscles. The earlier history of this case is unknown. This heifer was taken sick suddenly in a pasture to which the other cases had not had access and was the only case to develop in this pasture.

Alzanka.—June 8, quiet at 10–12 a. m. Neck around to the side as in parturient paresis. Could walk but was down most of the time. 3–5 p. m., down all the time, neck in the flank, quiet. 9 p. m., down with neck in flank most of the time; quiet, stupid, stertorous breathing.

June 9, 9 a. m., about the same as the previous night.

11 a. m.	temperature	100.8.
2:30 p. m.	"	101.8.
6:45 p. m.	"	102.8.
9:40 p. m.	"	101.8.

June 10, 7 a. m. temperature 100.8. Died at 10:30 p. m. Little change in condition until near the end.

Dell.—June 8, 11:00 a.m. quiet, down most of the time. At 3 p.m. lying in the yard, stupid, neck bent to one side. She was quiet, although the appearance of her eyes and condition of the cervical and facial muscles suggested a tension of the nervous system. Breathing at this time was stertorous. See Figs. 9 and 10. 10 p.m., temperature 101.5. Down, quiet but showing the usual symptoms in the face and neck. Loss of skin sensation, etc.

June 9, 9 a.m., apparently little change since last night. 2:30 p.m. about the same; 6:45 p.m., temperature 101.6; 9:50 p.m., temperature 103.4. This cow died at about 4 a.m. June 10th.

Countess.—June 8, 11 a.m. Respiration stertorous, re-

cumbent most of the time, but could walk. 2:30 p.m. pupil of right eye contracted, left eye dilated. 3 to 5 p.m. This cow was down most of the time, respiration stertorous. Could walk but the gait was quite irregular.

June 9, 9 a.m. Cow had died during the night and was found out doors having in some way forced her way through or under a very heavy sliding door. Evidently there had been intense activity before death.

Euroma.—This was a Jersey cow, giving normally at this time about 14 pounds of milk, testing 5 to 6 per cent butter fat. She gave on the evening of June 6, 5.1 pounds of milk, testing 6.2 per cent; on the morning of the 7th, 2.1 pounds of milk, 5.2 per cent butter fat.

On the morning of the 7th head was carried to the left; the left ear was more upright than the other and held back in a peculiar position, and the animal seemed stupid.

June 8, 9 p.m. Patient was standing grating her teeth and showing very marked spasms of the cervical muscles. The head was now turned around to the right and a portion of the right ear cold. She was not seen during the interval but supposed to be quiet and easy from what was learned of the attendant. At 9:05 p.m. this cow was found back of a spray pump in the runway, very stupid, weak and with poor circulation. She was in standing position and grating her teeth. Spasms of the cervical muscles were marked. This cow was apparently in very serious condition. At 10:00 p.m., there was great nervous excitement, the patient tearing around in a large room with short intervals of comparative quiet. Chewing motion, discharge of frothy saliva and convulsions of the neck and face muscles were continuous.

10:00 p.m. temperature 104.
10:30 p.m. " 105.
11:00 p.m. " 107.6

Died at 11:40 p.m. Note the very rapid rise of temperature.

Trudie Lee.—This cow gave no milk on the evening of June 10. June 11, 10:00 a.m., temperature 102; 1:00 p.m., temperature 101.8. This cow was apparently in good health on June 11, except that she showed the usual peculiar

expression of eyes and head. She was grating the teeth slightly; salivation was increased and skin sensation good, at least during forenoon; patient slightly dull.

June 11, 1:00 p. m. down. When made to get up she stretched and seemed to feel first-rate. The nose was moist. 6:00 p. m., temperature 101.6; neck at right side, hair rough; feet raised several times in a crampy way, nose moist. 9:00 p. m., temperature 102.6, wild expression in the eyes, and nose dry. She died during the night.

Examination Postmortem.—Only this one autopsy record will be given here. The findings in all cases were very similar and Trudie Lee may be taken as a type.

Trudie Lee a Jersey cow in good condition. She died early in the morning of June 12. The carcass was in fairly good condition.

There were hæmorrhages in several places on superficial parts, under scapulæ, etc. There were very marked hæmorrhages involving meninges of the medulla, but scarcely showing at all on the brain surface or in its substance. Multiple hæmorrhages were thickly scattered over omentum and mesentery, and there were several on the surface of the liver. The heart showed many small hæmorrhages on the surface; the right auricle being very markedly hæmorrhagic. On the costal pleura there were numerous hæmorrhages of varying sizes. The lungs were deeply congested in places especially in the region of the internal faces.

Lesions were all of marked hæmorrhagic character. There were two marked hæmorrhages between peritoneal and muscular coats of the uterus, which contained a normal five or six months fœtus.

COMMENTS ON CASE NOTES.

A survey of the foregoing case notes brings to light several interesting points. In the first place it will be noted that the temperatures were normal or subnormal rather than high, until a very short time before death when the temperature rose very rapidly, notably in the case of Euroma. The evidence on this point is not altogether satisfactory for in so many of the cases circumstances were such that temperatures could not well be taken during the last hour or so. In the Caffrey cases, where it was possible to follow the

case entirely through its course from the onset until the fatal termination, the temperatures were normal or subnormal throughout.

In the outbreak which occurred among cattle at the University Experiment Farm the disturbances of the nervous system were particularly marked, so much so that the diagnosis based on ante and post-mortem symptoms was unanimously considered to be a cerebro spinal meningitis.

Several of these cases at certain stages very closely resembled typical cases of parturient paresis. (See letter from Dr. Hela under "Caffrey Outbreak.") It should perhaps be noted that we had one cow taken sick with all the clinical symptoms of this latter disease, the symptoms appearing about 36 hours after parturition. (See "A Supposed Milk Fever Case.") This case appeared on May 28th and the cow died on the 29th, the diagnosis being parturient paresis. The potassium iodide treatment was given quite early in the case. The first dose of 10 grams apparently had no effect upon the course of the disease, and a similar dose was given about six hours later; this also without any apparent effect upon the case. The outbreak previously described as appearing among the dairy cattle belonging to the Univessity Experiment Farm appeared on June 8th, or about 11 days after this supposed milk fever case. No examination post-mortem was made of the latter but in view of the fact that several of the cases which appeared in the general outbreak among our cattle very closely resembled milk fever in all points except in the history of recent parturition, grave doubt has arisin in the mind of the writer whether the supposed milk fever case was not a cerebro spinal type of hæmorrhagic septicæmia instead of parturient paresis. The writer can well understand that a suspicion as to the accuracy of the diagnosis in an apparently typical case of parturient paresis may appear somewhat peculiar to say the least, but to those of us who saw the cases among our University Farm cattle it does not seem peculiar at all. There does not appear any reason why this peculiar type of hæmorrhagic septicæmia could not appear 36 hours after parturition as well as at any other period. If we consider the sudden checking of milk flow, the constipation, the posterior pa-

ralysis, the lack of skin sensation, the recumbent position with the head in the flank much of the time, the reason for doubting an apparently clear diagnosis may be easily ununderstood.

A peculiar fact which appeared in connection with our University Farm cases was noticed by the attendants, and every one who saw the case, viz: That the animals nearly all died in what they called "inverse ratio" i. e., the cases which were apparently most seriously sick early in their histories were the cases which lived the longest, whereas the apparently milder cases died very quickly and very unexpectedly. Those cases which were apparently most seriously sick were the ones which lived until the last ones of the outbreak. The Vye cow is an instance in point. If the brief convulsion on the morning of June 8th had not been seen, this cow would not ordinarily been considered sick at all beyond a very slight diarrœa.

Iris was standing in the yard drinking, switching flies, showing nothing whatever apparently wrong with her except slight listlessness as seen in the accompanying photo graph, and yet she died very suddenly and unexpectedly, without developing serious symptoms until a very short time before death.

In none of these cases witnessed by the writer has there been a rise of temperature, nor any tenderness of pressure over the spinal column more than elsewhere over the body, but quite a number have shown a hypersensitive condition of the skin in general. None of the cases seen by the writer presented unnatural heat at the base of the horns or throat paralysis. It will be seen that although the State Farm outbreak was unquestionably a cerebro spinal meningitis as proven by ante-mortem and postmortem symptoms, yet it differed in very many particulars from cerebro-spinal meningitis as it appears in the human family.

A CASE OF OVINE HÆMORRHAGIC SEPTICÆMIA.

A show sheep in fine condition 10 months old, which arrived from Canada about the middle of February, was noticed sick February 17th, died on the 18th. This animal was examined on the 17th about 4 p.m. The patient showed peculiar breathing there being two or three short, moderately full respirations and then a considerable interval. Respirations were not very rapid, and quite unlike an ordinary pneumonia. Neither nasal discharge nor cough was noticed. Temperature and pulse were not taken. This was supposed to be a case of common catarrh and not thought serious. The animal died very unexpectedly.

Autopsy.—Several bright, sharply defined hæmorrhagic areas were found on the inner surface of the skin, after removing an excessive amount of fat. There were no hæmorrhages on the superficial muscles. The small intestines were evenly and generally congested but this was comparatively slight. No hæorrhage upon any portion of the alimentary tract. Lungs were as if they had been taken from a hog during an outbreak of hog cholera and swine plague, and were typical of the latter disease. The collapsed areas amounted to probably one-third of the entire lung substance. The heart showed extensive hæmorrhagic infiltrations especially the auricles. Report from Dr. Wesbrook, director of the Bacteriological Laboratory of the State Board of Health, was to the effect that pure cultures of *Bacillus bovisepticus* were recovered.

SUPPOSED MILK FEVER CASE.

A Jersey cow, high dairy type, belonging to the University Experimental Farm, calved May 28. She was noticed sick on May 29, and when seen by the writer had lost voluntary control of the limbs; skin sensation was poor over most of the body surface. She was rather quiet with the head in the flank, and the usual retention of feces and urine. Iodide of potassium 10 grammes was dissolved in a quart of warm water at 10:30 a. m. May 29th. One-fourth of this was injected into each gland. This treatment apparently had very

little effect and the dose was repeated at 9 a. m. May 30th. This second dose was practically without effect and the cow died some time during the same afternoon. We did not expect the cow to die at this time and she was not seen during the last few hours. In view of the symptoms which were seen in one general outbreak of hæmorrhagic septicæmia where several cases very closely simulated milk fever, the suggestion may not appear unreasonable that this case was either not a case of milk fever or else, if you please, a case of milk fever caused by the same germ which was apparently responsible for the development of other cases, which appeared later. See University Farm Outbreak.

SUSPECTED OUTBREAKS NOT UNDER THE PERSONAL OBSERVATION OF THE WRITER.

Mr. Wm. L. Hoover, Faribault, called at my office on Dec. 29th and said he had 17 head of cattle coming two years of age and had lost four; the first case about Dec. 1st, and the last one about Dec. 27th. The first three died within a week, leaving quite an interval before the fourth one died on Dec. 27th. All of these animals died very suddenly. The owner noticed on skinning the animals hæmorrhagic areas on the body surface, particularly on the neck, and stated that a similar condition may have been present in every case, but it was not noticed. He did not know whether similar areas had appeared upon the vicera or not. Had not thought of this in making an examination and did not look for them.

Mr. E. G. Stark, of Silver Creek, Twp., Wright Co., came to see me on Dec. 29, concerning the loss of cattle in his neighborhood. He reported that Mr. Isaac Carter had lost three cattle in about a week—out of a total of twelve head. This occurred just before Christmas. The first one died in about six hours after having been noticed sick. The two others also died very suddenly. He could give no information concerning the postmortem conditions, but stated that the cattle had been fed on shocked corn and kept in the stable and yard.

Later I recived a letter from Mr. Stark, dated Jan. 28,

giving more definite information concerning losses among Mr. Carter's cattle. He states that the first one died about Dec. 10. It had been found sick in the morning and died about 3:30 p. m. The second died about ten days later. On coming up a hill on its return the animal stumbled and fell over dead, and as he states, "it did not even kick after falling." This was a two year old steer. The third animal died about four days later. This one was taken sick at about eleven in the morning and lived until four o'clock the next morning, suffering very severely, at least so the owner supposed. This probably means that the animal did considerable struggling and possibly groaning while down. The fourth animal was a young cow, and as he expressed it, "she also died hard." About Jan. 5 or 6, two animals were found dead in the barn in the morning and the next morning two more animals were found dead. None of these four last animals had been noticed sick. At the time of this outbreak Mr. Carter had 16 head of cattle and lost eight. The owner informed Mr. Stark that those cases which had lived long enough to give an opportunity for observations had seemed very tender to the touch, particularly over the spine and near the base of the brain. The heads were drawn as far back as possible and the eyes "rolled up." The animals that died had been fed corn on the stalk.

One interesting bit of information in connection with this outbreak was to the effect that the owner had these eight animals drawn out just behind his stacks within a few yards of the barnyard after having removed the skin, and that no further cases appeared. One of the neighbors who skinned most of these animals for Mr. Carter had a nice lot of cattle, but his cattle receiyed no infection.

Mr. Peter Nelson had lost eight and killed two out of a total of seventeen head. The first case appeared early in November. The deaths with the exception of two, came very close together. These two died a week or so later. No careful examination postmortem was made, and no further information was obtainable from Mr. Nelson.

Mr. Jens Sorenson, of Monticello, wrote me on December 7 concerning some disease among a neighbor's cattle. His letter was to the effect that a certain neighbor had lost eight

cattle, and other neighbors (full information not given) had lost cattle from this disease. Some of these cattle which the owners had supposed to be in perfect health had dropped suddenly and died practically without struggling. Others had lived a few hours after being taken sick. The neighbors had noticed that these which lived for a few hours appeared very sensitive along the spinal column. This is very meagre information of course, and may pertain to either hæmorrhagic septicæmia, meningitis or corn stalk disease if there is such a disease.

Richard Anderson, Belle Plaine, Paxton township, Sibley Co., living two miles north of town, had eleven head and lost four. The first one died about November 13th, the last one November 29th. None were sick at the time the information was received. The period of sickness was given as approximately three hours, but varied. The owner stated that the head was drawn backward after the animals went down; dark red areas were noticed under the skin, but no spots were seen on the internal organs. His cattle were confined to the yard and usually given dry feed, including shocked corn fodder. Mr. Anderson noticed also the peculiar grunting expiration, unusual sensitiveness of the body surface under pressure, and that the animals were disinclined to walk around, being apparently sore. He described the typical condition of the intestines and rectal mucous membrane.

A Comparative Study of Hæmorrhagic Septicæmia, Anthrax, Symptomatic Anthrax (Black-leg) and Cerebrospinal Meningitis.

	Hæmorrhagic Septicæmia	Anthrax	Symptomatic Anthrax (Black leg.)	Cerebro-spinal Meningitis.	REMARKS
Act. organism	Bacillus bovisepticus.	Bacillus anthracis.	Bacillus chauvoei.	Diplococcus intercellularis Diplococcus pneumoniae.	
How spread	Unknown.	Any infected object.	Food, water, carcasses, discharges, etc.	Uncertain, probably food stuffs.	
Extent of spread, (single outbreak)	Localized.	*Wide spread.*	Local.	Local.	
Infection	Unknown.	Digestive organs, respiratory organs, and inoculation.	*Inoculation.*	Probably digestive organs, and possibly respiratory organs.	
Season favoring	Indifferent.	Hot, dry summer, following wet spring.	Summer and fall.	No information.	
Susceptible animals	Very general.	Very general.*	Young cattle, sheep and goat.	Cattle, horses, sheep, goat and dog.	*Swine, but slightly susceptible.
Mortality, per cent	80-90	80-100	80-100	80-90	
Symptoms.					
Onset	Sudden in acute, slow in chronic.	Sudden.	Sudden.	Usually sudden.	
Local swellings	Slight or absent.	Rare in acute cases,* *no subcutaneous emphysema.*	Usually marked and *emphysematous.*	Absent.	*May be present in other cases.
Urine	Sometimes blood stained	Frequently blood stained or dark.	Sometimes blood stained or dark.	Normal appearance.	
Feces	Frequently blood stain'd	Frequently blood stain'd	Constipation, intestinal contents bloody.		
Autopsy.					
Blood, (general circulation)	Normal appearance and coagulation.	*Dark or muddy, feeble coagulation, doesn't red'en in air*	Normal color and coagulation.*	Usually normal appearance and coagulation.	**From tumor, dark, frothy and fetid.*
Hæmorrhages	Usually present, general, clearly defined.*	General, nearly all org'ns	Not general, may occur in heart, lungs and subcutaneous tissues.	Reported, but diagnosis is questioned.	*Vary greatly in size and intensity.
Serous cavities	*Hæmorrhages frequent.*	Reddish serum usually present.	Serum may be present, especially in abdominal.	May contain serum.	
Spleen	Normal except superficial hæmorrhages.	*Enlarged, dark soft.*	Normal.	Normal.	
Subcutaneous gas, (soon after death)	Not present.	Not present.*	*Present before and after death.*	Not present.	*General, decomposition rapid.

DIAGNOSIS.

It is very important to distinguish between black leg and hæmorrhagica septicæmia, because so far as our present knowledge extends, we are practically helpless in the presence of hæmorrhagica septicæmia. We know almost nothing concerning the method of its spread, method of infection, and we have no vaccine either preventive or curative, and no medicinal treatment; whereas black leg can be easily and cheaply prevented by vaccination. The diagnosis must depend upon the history and what can be learned of the ante-mortem symptoms and the results of examinations post-mortem.

Differential Diagnosis.—So far as the facts occur to the writer at present, the differential diagnosis comes between hæmorrhagica septicæmia, black leg, true anthrax and possibly corn stalk disease, if there is a disease which is any longer entitled to this name. There can be no question but that hæmorrhagica septicæmia has been frequently confounded in the past with other diseases, particularly black leg and true anthrax. Anthrax has been so very rare in Minnesota during the past ten years that I will leave it out it of the discussion in order to simplify. There is developing a grave question as to whether there is such a disease as corn stalk disease. This narrows the differential diagnosis down to black leg and cerebro spinal meningitis, either of which might be easily confused with the disease under discussion.

In my discussion of the distinction between black leg and hæmorrhagica septicæmia I will have nothing to say concerning laboratory work, because very few stockmen in the event of an outbreak of hæmorrhagica septicæmia or black leg have access to bacteriological laboratories. I do not wish to give the inference that I underestimate the importance of laboratory work; on the contrary, a diagnosis in the bacteriological laboratory may be positive, accurate, and in some cases the only means of making an accurate diagnosis.

The ante-mortem differential diagnosis, exclusive of laboratory findings between hæmorrhagica septicæmia and black leg must evidently be based upon the history of the cases, ages of the animals affected, temperature records as shown by fever thermometers and local superficial swellings,

and the examination and appearance of the blood taken from the tumor in case such lesion is present.

In both diseases death is liable to occur very suddenly, but black leg commonly affects only cattle under two years of age, whereas hæmorrhagica septicæmia affects all ages indiscriminately. High temperatures are characteristic of black leg, especially early in the history of the cases, whereas, in hæmorrhagica septicæcia the temperature in my experience has been normal or sub-normal until near death, and then in some cases rising very rapidly. A pronounced swelling of the front or hind quarter is rather characteristic of black leg, though in a few cases which died very suddenly there may be no noticeable swelling. These cases usually occur early in the history of the outbreak, and following them there are almost invariably other cases which show the characteristic swellings of black leg or black quarter, as it is frequently called. Swellings of this kind are not characteristic of hæmorrhagica septicæmia, and when present at all are small.

Blood taken from a black leg tumor is dark, frothy and with disagreeable odor, whereas the blood taken from a case of hæmorrhagica septicæmia, even from the small swellings which sometimes occur, is apparently normal. It reddens on exposure to air, clots readily and does not seem to be changed. It should be noted that this is also true of blood taken from general circulation in the case of black leg. But the important point of difference is the character of the blood taken from the swelling in a black leg case, which blood is very abnormal.

There is another point which has some bearing in distinguishing these two diseases. Hæmorrhagica septicæmia occurs at any season of the year, whereas black leg is most apt to occur in the summer and fall.

A diagnosis between these two diseases may, as a rule, be quite easily made by examination postmortem. Here we have in a case of hæmorrhagica septicæmia the characteristic hæmorrhages which appear as blood-stained or bruise-like areas under the skin; and sharply defined blood-stained areas on the internal organs or the linings of the body cavities.

Treatment of Hæmorrhagic Septicæmia deserves no discussion for so far as our present information concerning the disease extends it is a waste of time and medicine, although it is true that the two animals, Alzanka and Dell (University Experiment Farm Outbreak), received full doses of nerve sedatives, and lived very much longer than other cases, but terminated in death just the same.

GENERAL CONCLUSIONS.

For the present at least we must consider the term "hæmorrhagica septicæmia" as quite inclusive, a sort of generic name which must cover a multitude of widely varying types of disease, but perhaps in all of which the specific microorganism *B. bovisepticus* is found, and so far as our present information is concerned we are apparently justified in considering this germ as the specific cause of the widely varying types. It is also safe to assume that it is not by any means a new disease, the only new feature about it being probably its definite diagnosis by Dr. Wilson of the Laboratory of the Minnesota State Board of Health. Very many outbreaks of this disease have unquestlonably been diagnosed as corn stalk disease, black leg and anthrax.