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AGRICULTURAL EXPERIMENT STATION.

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Siloing Clover. Sources of Home-made Manures. The By-Products of Wheat. The Rocky Mountain Locusts in Otter Tail County, Minnesota, in 1889.

The Bulletins and Annual Reports of this Station will be sent free to residents of this State who request them.

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AGRICULTURAL

EXPERIMENT STATION

OF THE

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INTRODUCTORY.

This experiment station has been under my direction three months. The work attendant upon beginning any undertaking is considerable. An acquaintance with one's resources is essential. Deciding upon the best and most economic methods for getting the best results takes time.

In this regard, beginning the work of director of an agricultural experiment station furnishes no exception to the common experience. My time has been fully employed in doing that which is necessary to be done, at the beginning.

The operating and incidental expenses have been reduced to the lowest point consistent with efficiency.

Only such kinds of experimental work will be continued or begun in the different divisions as promise to be of practical value to the people of the state.

In deciding upon the line of work to be undertaken at this experiment station, I have not only borne in mind the urgent need for discovering better methods and practical improvements in the practice of those branches of husbandry already introduced in this state, but due consideration has also been given to the claims of those branches of husbandry which soon may become fruitful sources of agricultural wealth and permanent prosperity. New and strategic methods in production and utilization will be devised and tested. Methods and practice, the value of which has elsewhere passed beyond the region of doubt, will also be subjected to trial under the physical conditions prevalent in Minnesota, and the results of such trials and experience tabulated and published.

It is the design of the board of regents that this experiment station shall be thoroughly equipped and ready to meet the demand for practical experimental work, and that it shall be in the highest degree servicable to the people of the state, for whose benefit the station was established.

During the past three months the entomologist of this station has been chiefly employed in the work of exterminating the Rocky Mountain locusts which threatened destruction to the growing crops throughout a wide area in this state. A full account of the methods employed and the success attending the work is given in this bulletin.

With the passing of the meat inspection bill came the demand for qualified inspectors.

With the consent of the board of regents, I established a school for meat inspectors, in charge of Dr. O. Schwartzkopff, veterinarian of this station,

in which practical instruction was given in those sections of veterinary science—illustrated by slaughtering and dissection of diseased animals—suited to qualify men for the duty of "inspection on the hoof." This course was attended by thirty-four men, from many different counties in the state. Assisted by the veterinarian I conducted a written and oral examination at the close of the term, and twenty-one were found qualified for the duty of meat inspector and were given certificates certifying to such qualification.

The economic importance of the silo is a question which is now engaging the attention of the most progressive agriculturists. The stock-growers and dairymen of this State will be interested in the experiment in siloing clover, an account of which is given in this Bulletin; and a more complete history of the experiment and the results obtained will be duly published.

Every tiller of the soil who realizes that the soil of the State of Minnesota is being steadily robbed of its fertility by the system of agriculture in common practice, will be glad to know of the value of the by-products of wheat, and the available sources of home-made fertilizers; and now that a general interest has been awakened in diversified farming, the information herein given concerning these subjects is valuable and exceedingly opportune.

Fully realizing the difficulties in the way of those who undertake the task of dealing with the slow and intricate processes of nature, and bespeaking for the force of this station the helpful suggestion and kindly encouragement so grateful to all patient investigators, we address ourselves to the work before us.

N. W. McLain,
Director.

SILOING CLOVER.

N. W. M'LAIN.

Farmers, stock-growers and dairymen are not more interested in improved varieties of forage crops and improved methods of cultivation than they are in saving and utilizing them. Indeed the question fronting us to-day is not so much a question of abundant and economic production as a question of economic saving and utilization.

The proposition that nearly or quite forty per cent. of the value of all the forage crops raised for domestic consumption in the United States is totally lost by careless, untimely and unscientific methods in harvesting and saving, by wasteful and unskillful methods in feeding, and by feeding to unprofitable stock, would find few disputants among those conversant with the facts.

The question then of how to save our forage crops, with the least hazard and loss, and so that they will retain the highest per centage of their food value and palatibility, is one of the highest practical and scientific importance. Of the varieties of forage plants successfully grown in the United States, both on account of the superior quality of the food and also its value as a fertilizer, clover stands among the first.

The adaptability of clover to successful cultivation under a very wide range of conditions, such as quality of soil and length of seasons, commends it to farmers in nearly all parts of the United States, and the value of the crop amounts to a significant figure in the aggregate value of forage crops. Clover is exceedingly susceptible to damage from the incidents attending harvesting. Not unfrequently in many seasons fully one half of the entire crop of clover is more or less damaged or ruined before it can be secured in stacks or barns. This fact suggests the necessity for a practical method for securing the crop without damage, and in such a manner that much of its original aromatic flavor and delicious taste is retained.

To this end experiments have been made in siloing green or partially cured clover. Careful observation and persistent intelligent trial make a skillful practitioner, but if the lessons of experience and the result of experiment are not recorded, the experience and skill are lost when the practitioner dies. It is by recording observations and experience, and by tabulating facts that we add to the knowledge of our profession and assist in building up a science of agriculture.

Experience is many sided. That which to-day may challenge our skill and experience to-morrow may readily yield to our own or the experience and skill of another.

In order that this station may contribute something practical to the store of information which is being gathered concerning curing and preserving clover, I built a hay silo 24 feet long by 20 feet wide, and 24 feet deep,

with sills 6 x 8 inches, with one cross sill framed into the side sills 12 feet from either end, upon which rests the partition, making two bins 12 feet wide by 20 feet long. The studding are 2 x 8, 24 feet, doubled at the corners, with plates of 2 x 8 doubled. The roof is half pitch, wiih carrier for horse hay fork suspended as closely as possible under the comb, projecting beyond the end walls, as is customary. Just above the plate at either end is a large door for the admission of the clover. The walls are built after the usual manner of constructing silos above the ground. First, a lining of matched flooring is nailed to the studding on the inside of the outside walls, and on the partition studding in the silo. Then a lining of building paper and then another lining of matched flooring well nailed on covers the paper. The outside wall consists of bevel matched siding, with corner boards. For convenience in removing the contents of the silo, two 2 x 8 studding are left out of each end wall of the building directly in the middle, and sections of the inner linings and outside wall are cut out and made adjustable so as to fit tightly into the spaces from which they are taken, the sections of the outer lining being hung on strap hinges. The silo was filled with solidly packed earth to the depth of eight or ten inches for about two feet from each wall. It was my intention to cut and store the clover when about one third of the heads had turned brown from ripening, but delay in completing the silo compelled me to defer the cutting until somewhat more than one half the blossoms were quite brown. The clover with a slight mixture of timothy was cut as early as the dew was off in the morning, and as soon as the leaves were wilted it was raked and loaded. The timothy was just shedding the blossom. In four days prior to July 15th eighteen and one half tons were stored in bin No. 1, filling the bin one foot above the plate. July 16, 17 and 18, twenty-two and one quarter tons were stored in bin No. 2, filling it to within four and one half feet of the plates. The clover in bin No. 2. was nearly free from timothy, and was raked and loaded almost as soon as cut. Upon the average the clover stored in bin No. 1 was not as well ripened as that in bin No. 2, and the rake closely followed the mowing machine. Most of the clover in bin No. 2 was loaded on the wagon in from thirty minutes to one hour from the time it was cut, which accounts for the greater weight of clover in bin No. 2, occupying nearly one fourth less space than that in bin No. 1. Two wooden tubes were placed in each bin, one near the center of each bin and one three feet from the south-east and north-west corners of the silo. The clover was evenly spread while filling the bins and kept thoroughly tramped, especially along the walls of the bins. As soon as the clover had partially settled, dry straw was spread over each bin to the depth of two feet. A layer of boards was spread over the straw in bin No. 1, and the boards lightly weighted. No covering except the dry straw was used in bin No. 2. The wooden tubes before mentioned extend from the bottom of the bin to one foot above the plates, and auger holes are bored through the spouts one foot apart the whole length. In the spouts are suspended thermometers for taking the temperature four, eight, twelve and sixteen feet above the bottom. Ten days after filling the clover in bin No. 1 had settled eight feet, and in bin No. 2, six feet six inches. July 26 the temperature in the two bins was as follows:

Bin No. 1.		Bin No. 2.	
4 feet above the floor	160	4 feet above the floor	150
8 " " " "	150	8 " " " "	158
12 " " " "	140	12 " " " "	160
15 " " " "	118		
	July 29:		
4 feet above the floor	150	4 feet above the floor	150
8 " " " "	145	8 " " " "	154
12 " " " "	136	12 " " " "	156
16 " " " "	116		
	July 31:		
4 feet above the floor	146	4 feet above the floor	150
8 " " " "	144	8 " " " "	150
12 " " " "	130	12 " " " "	152
16 " " " "	112		

Steam came from the tubes, and the heat at the top was more than could be borne by the hands. More steam came from the tubes in bin No. 2 than from bin No. 1, the clover being greener in bin No. 2 than in bin No. 1.

Where suitable preparation has been made, and care and good judgment used in the trials for preserving green clover and other green grasses, encouraging results have been obtained.

A trial in which a larger tonnage of clover was used than in any other which has come to my notice was made by Mr. C. McLain, a farmer and feeder of large experience, of Franklin County, Kansas. Mr. McLain built a silo barn 50 feet wide by 74 feet in length, the main bin of which is 30 feet by 74 feet, 20 feet deep.

After giving dimensions he writes: "If I were to build again I would make the bins deeper. Last year was favorable for such experiments. We had no rain during haying, very little dew. No rule can be laid down as to how dry the hay should be. It will keep very green if the air is excluded and neither dew or rain on the clover. I finished filling about June 15th, and the grass was clear clover, and but few heads were turned brown. I cut after the dew was off and put in silo that afternoon. The clover was thoroughly wilted, partially eured, I should say, but the stems were green. When taken out of the silo the clover was a light brown color. I cut out a block from the center of the bin and took it to a farmers' institute. All said they never saw such hay. I know I never did. It was sweet, and some called it sweet ensilage. The odor was wonderfully strong and agreeable. Considerable clover was spoiled at the bottom, probably because the air was not sufficiently excluded. The silo should be as completely air tight as it is possible to make it. I believe steers well sheltered would make weight fed on on this clover without any grain. My hay silo barn has attracted considerable attention, and there is a great deal of interest among farmers and feeders in this state concerning the best method for preserving clover, and I am asked a great many questions in regard to it which I am not prepared to answer."

It is for the purpose of solving some of the many intricate questions about preserving clover that this experiment was undertaken. I hope if the season is favorable for the growth of clover that I may be able to get some second crop for filling the space remaining unfilled, and vacant space caused by settling. A completed history of the experiment and the result will be given in future bulletins.

SOURCES OF OUR HOME MADE MANURES.

WILLET M. HAYS.

Very large amounts of wheat, flour, bran, shorts, oil cake, and other products are annually shipped from our State. Immense quantities of hay, oats, etc., are taken from our farms to our towns and cities, a large part of which is never returned to the land in the form of fertilizers, and such great quantities of fertilizing materials are yearly wasted by burning straw stacks, allowing manure to waste in barn-yards, or are not otherwise returned to the soil that the decrease in fertility is alarming; and our soil is constantly made poorer by the present system of agriculture. That this is not a necessity is proved by the many farmers in this and other States and countries, who succeed in retaining the fertility of their land, by rotating their crops, plowing under green manure crops; and by converting feeds into live stock and other finished products, thus returning one-half to nine-tenths of the plant food removed in crops to the land in the form of manure.

To clearly bring out numerous facts in this connection, the following tabular statement was prepared, showing what values the farmers in older sections of country, where the lands have been worn out by constant and long continued cropping, are paying for commercial fertilizers containing similar substances to those contained in the various products named in the table. The annual productions of the several crops in column II. are from the last report of the Commissioner of Statistics, Mr. H. Stockenstein, Assistant Secretary of State, while a few, marked with an asterisk (*), are estimated by the writer. The amounts of nitrogen, phosphoric acid and potash in each product are estimated from average per centages given in Harris' Talks on Manure, and from later publications; and in a few cases, also marked by asterisks, these are estimates by the writer.

The three substances considered, in Eastern States and in some European countries, where large quantities are annually used by farmers, in calculating the value of commercial fertilizers, are nitrogen, potash and phosphoric acid. The wholesale value there is about 12 cents per pound for nitrogen and 4 cents per pound for potash and phosphoric acid: to this is added about 20 per cent. in estimating the retail price, to cover handling, profits, collections, etc. The experiment stations in the older States which, to prevent fraud, exercise control over the sale of fertilizers, multiply the amounts of nitrogen, potash and phosphoric acid, found by chemical analysis, by the above prices, to show the farmers the comparative values of the different brands of fertilizers offered for sale in their respective States.

TABLE—*Showing the annual production in Minnesota of the principal grains, meats, by-products, etc.; their content of the three principal fertilizing ingredients, nitrogen, phosphoric acid and potash; their value per ton, reckoned at prices in New York and Boston; and their total and comparative value as fertilizers.*

I.	II. Amount Produced	III. Amount Reduced to Tons.	IV. Nitrogen contain'd pounds.	V. Phosph'c Acid. pounds.	VI. Potash. pounds.	VII. Fertl'zr Value. per ton.	VIII. Total Val as a Fertilizer
Wheat, bushels	39,070,159	1,172,105	48,056,305	20,933,469	12,893,155	$6.08	$7,126,398
Oats, "	37,661,424	602,633	23,141,007	5,303,170	7,472,619	5.25	3,163,823
Corn, "	17,234,422	482,564	15,442,048	5,694,255	3,571,074	4.61	2,204,620
Barley, "	5,216,397	125,144	4,004,608	1,927,238	1,126,296	4.80	606,691
Flax, "	1,318,121	36,907	2,418,099	996,484	738,140	9.75	359,843
Rye, "	255,571	7,155	251,856	119,204	80,136	5.34	38,208
Buckwheat"	108,704	2,282	65,721	26,015	12,323	4.11	9,379
Beans, "	21,235	637	51,979	15,116	16,689	11.79	7,506
Timothy Seed, bu	275,144	6,190	* 247,600	* 43,330	* 68,090	5.52	34,169
Clover Seed, "	38,480	1,104	67,344	32,016	29,808	9.54	10,532
Potatoes, "	4,920,735	147,622	1,003,830	472,390	1,672,891	1.11	163,860
Cult. Hay, tons,		390,100	12,093,100	3,198,820	10,298,640	5.10	1,989,510
Wild Hay, "		2,120,526	*31 807,890	*25,446,312	*29,687,364	2.84	6,022,293
Wheat Straw" *		1,758,157	19,339,727	7,032,628	38,699,454	2.38	4,184,412
Oat Straw, " *		1,054,457	11,809,918	4,806,937	18,769,335	2.20	2,539,805
Corn Fodder," *		965,128	9,265,211	10,230,357	18,540,458	1.75	1,688,973
Barley Straw" *		187,716	2,402,765	713,321	3,518,061	1.98	360,678
Butter, pounds,	28,117,172	14,585	25,670	16,230	17,500	29	4,299
Cheese, "	1,074,251	537	48,652	12,351	2,685	12.70	6,820
Skim Milk, " *	1000000000	500,000	5,100,000	1,500,000	1,700,000	1.48	740,000
Wool, "	2,265,665	1,133	121,364	2,493	169,044	19.02	21,549
							$31,283,362
Milk *		1,000,000	10,200,000	3,000,000	3,400,000	1.48	1,480,000
Bran		195,351	8,751,725	5,687,039	10,666,165	8.61	1,681,972
Shorts		50,401	2,232,764	* 549,371	*1,048,340	7.70	388,088
Screenings		58,605	2,803,040	*2,930,250	*703,260	7.08	414,923
Fatted Cattle *		75,000	3,990,000	2,790,000	255,000	8.00	600,000
Fatted Hogs *		25,000	1,000,000	440,000	90,000	5.65	141,250
Fatted Sheep *		5,000	224,000	123,000	15,000	6.48	32,400

It is not here assumed that these substances are as valuable per ton for manure in Minnesota as the figures in column VII. represent, but that farmers in the East are actually purchasing at these and even higher prices. The figures representing value per ton are worthy of study, as they show approximately the relative values of these different products for manure, as well as the importance of returning them to the soil; and the table clearly indicates which products most drain the fertility of our lands.

Estimating the value of average barn-yard manure by the same process as was used in constructing the table (nitrogen at 12 cents and potash and phosphoric acid each at 4 cents per pound) we find a ton worth $2.05, which, of course, is more than it is worth on the cheaper lands of the Northwest. Even considering barn-yard manure worth 75 cents per ton and the substances given in the table of proportionate value, under average conditions in Minnesota, and we see what a chance there is for an enormous waste. And each farmer can calculate in which crop he is removing the most value to the elevator, to the manure pile, or to the neighboring stream. This waste effects not only the crops of the next few years, but those of the next generation even more, since lands once run down can be enriched only with great expense, while rich lands produce materials with which the farmer can "feed the land."

Column VIII. is of interest, since from it we can easily see which of the various productions are carrying most of the value from the land of

the State, and which removes least. Reference is often made to the great drain upon the land by continuous cropping to wheat, oats, flax, etc., but our farmers have as yet only begun the careful consideration of how to prevent the excessive losses to fertility now taking place. Some even assert that there is hardly such a thing as exhaustion of their deep soils, like that in the Red River Valley; although the fertility of some of it is wonderful, it should be kept in its original condition. Those who think our lands too rich to need manure should inquire in the older settled sections of the Red River Valley, and other places having most excellent virgin soils, and see the new raw lands selling considerably higher than the adjoining improved(?) lands, which have borne a number of crops of wheat.

The manurial value of our great quantities of wild hay, straw of various kinds, and other products of lesser amounts, have received but little attention. The practical question is: which of these products can we return to our lands and which must we sell? The entire system of our farm management is involved in an intelligent answer. The manure from most animals contains from 75 to 100 per cent. of the fertilizing ingredients of their feed, and in a most excellent form for manure. There is often some loss during the process of rotting coarse bedding material mixed with the solid and liquid excrement.

The flour of our wheat contains nearly two-thirds of the manurial value of the grain. The other one-third is in the bran, shorts and screenings, and all of these produced in the State can economically be fed here. They are now mainly shipped to Wisconsin, Illinois, Iowa, and States further East, and inventors are trying to develop a process for compressing bran and shorts, so that they can be shipped to Europe, and they are now very hopeful of success. Large amounts of oats are shipped from some parts of the State, which, if retained and fed to horses and other animals, would not only be a profitable practice in itself, but would also aid in enriching the land. Most of the corn raised in the State is consumed, and it all could be used with profit in the production of beef, pork, mutton and milk. Rotating, in favorable localities, our wheat lands with corn, not only gives the land a rest, but with corn crops, stock and manure come as further aids to enrich the land for wheat crops. A large proportion of the barley raised is shipped out of the State, local breweries using some, and considerable is profitably fed to hogs and other stock.

In case of the flax our lack of appreciation of a valuable feed and manure is most forcibly illustrated. We raise 1,318,121 bushels (more now), and 800,000 bushels are pressed in this State at the two mills, Minnesota Linseed Oil Co., Minneapolis, and the Mankato Linseed Oil Co., Mankato. These two mills make annually about 16,000 tons of oil cake, of which about 4 per cent. is fed in Minnesota, 4 per cent. in other Northwestern States and 92 per cent. is shipped directly to England! The wholesale price of cake at the factories is about $20 per ton, and the retail price but little higher, or the same price per ton as oats at 32 cents per bushel. Farmers in England feed oil cake to sheep kept in hurdles on turnip fields and pay thirty dollars or more per ton for it, realizing that the manure will pay most of the bill. With our straw, corn fodder, ensilage and other very cheap feeds, deficient

in protein (muscle-formers), all the cake raised in the State should be fed at home. It enables the feeder to economically feed more of the cheap, rough feeds, composed mainly of carbo-hydrates (heat producers).

Buckwheat, beans, timothy seed, clover seed, potatoes, cheese and butter, either are produced in such relatively small quantities, or are of such a nature as not to take a great amount of fertility from our lands, though from the individual farm some of them might make a serious drain. A ton of butter, worth three to five hundred dollars, contains only a few cents worth of fertilizing material. Milk, however, contains a very large amount of substances fit for plant food. Skim milk should be fed in such a way as to make money from the young animals consuming it, and the manure from these should be carefully husbanded.

To stop the exportation of so much of the fertility of our excellent soils, we must, in a more diversified system of farming, condense our freights into meat, butter, cheese, flour, etc., as near to the farm as possible, using all the by-products, also rich grains, as oats, barley, bran, etc., for feeds, and eventually as manure. To stop the throwing of manures into streams in our cities, the "leaching" of manure piles in sloughs, the burning of straw stacks and the every day waste of substances fit for manure around our farms, we must simply learn to husband the small things. Diversified farming, an increase of our country and country town population, encouragement of home or "country town" manufactories of flour, machinery, etc., will not only assist in retaining the fertility of our lands, but in the end will conduce to the wellfare of our entire agricultural, commercial, manufacturing and transportation interests. Deplete our lands and we have nothing to sell, deal in, or transport.

Much of our great State is adapted to raising better wheat than any other large part of this country, if not of the world. Farmers in the Red River Valley, for instance, can continue to make money out of wheat, unless some dire calamity befall that section of country, but it is not the best way to do this by raising nothing but wheat. Let the wheat there be the principal crop to bring in money to the farm, and then keep up a rotation of crops, as pastures, meadows, peas, and other forage crops, which rest the soil by rotation, and after being fed to animals may be returned to the land to keep it in "heart" for wheat. These crops as pastures etc., and stock raising, dairying, and other lines of farming which keep up the fertility of the land, may even not pay very well of themselves, but if they merely pay their own way, in providing a part of the living of the family, and in bringing in money for meat, butter, etc., furnish employment in winter; and keep the land in such condition that two to three good crops of wheat can be produced on the land every five years, enough money can be made out of the wheat to make farming pay. These lines of farming which must go with wheat farming to assist it must receive better attention than our frontier wheat farmers are wont to give to anything but wheat, and when properly managed there is money to be made out of many of these lines, besides the assistance they are to wheat, even in the extreme North part of the State.

Experiments regarding many questions in economical feeding are receiving attention at the Station, and later reports will deal with composting manures, and the crops to which they may be best applied; the last being of especial importance in the Red River Valley district, where the rain fall is not sufficient to rot uncomposted manure applied to the soil.

THE BY-PRODUCTS OF WHEAT.

W. M. HAYS AND D. N. HARPER.

Careful estimates show that the out-put of the flour mills of Minnesota is equal to or greater than the entire wheat product of the State, much of the wheat ground coming from Dakota and elsewhere, resulting in an immense production of the by-products of wheat. The mills of Minneapolis alone produced last year 7,056,680 barrels of flour, requiring something over thirty million bushels of wheat for that purpose, or about three-fourths as much wheat as is grown in the State. The large quantities of bran, shorts, screenings, "cockle," etc., thrown upon the markets as by-products, for feed, led us to investigate the manner of manufacturing and selling these materials, and to make chemical analyses of them.

The wheat grown annually in Minnesota yields about 200,000 tons of bran and 50,000 tons of shorts, and from the wheat there is taken, as estimated from an average year, about 75,000 tons of screenings composed of small or light grains of wheat, wild buckwheat, fox tail and numerous other weed seeds, also some broken straw, chaff and other dirt. The bran as now produced by roller mills is merely the outside covering of wheat, with almost none of the flour attached to it. The shorts is little else than the finest bran, and contains only a small amount of the floury particles which was the characteristic feature of shorts made by the old process of grinding, before machinery was perfected so as to rub the last grains of starch and gluten from the inner surfaces of the bran and to pulverize all the embryo of the grain into flour. The amount of bran and shorts fed in the State and the amount shipped out could not be satisfactorily estimated. While our farmers are rapidly increasing the home demand for these valuable feeds and fertilizers, much more than half that produced in the State goes to Wisconsin, Iowa, Illinois and States farther eastward, where the farmers would hardly know what to do without it for feed and fertilizers.

The screenings are separated from the wheat, sometimes by the farmer, by the country elevator or by the terminal elevator, but more frequently by the mill. In fact most of the wheat must be cleaned at the mill, even if cleaned by both the farmer and the elevator, mainly on account of the lack of suitable machinery for cleaning in the country. Screenings are constantly gaining in popularity with farmers for feeding to all kinds of stock. Even horses are found to do nearly as well on screenings costing seven dollars per ton, as on oats, worth in the market two or three times that sum. Ground

screenings have proved most excellent and economical food for cows, as is asserted by many dairymen in the vicinity of the Twin Cities, who mainly depend upon this source of supply for grain feed. Sheep are fed in large numbers on screenings, with only an occasional feed of wild hay to prevent scouring, which happens where the screenings contain too large a proportion of "rusted or frosted" wheat. 35,000 Montana sheep were fed at one suburb between St. Paul and Minneapolis in this way the past winter and fine profits were made. Flocks of 5,000, more or less, were fed at other places in the State. Wheat farmers in the northwest part of the State are coming to look largely to wheat screenings as a feed for hogs, and not only stock hogs thrive on it but it serves well for ripening hogs for market, making most excellent meat. Nothing is better feed for poultry than wheat screenings, and all enterprising farmers in sections where much wheat is grown have an abundance of poultry and eggs, produced mainly by this feed. For all animals, unless it be poultry and sheep, the screenings should be ground, preferably with a roller mill, so that all weed seeds are destroyed. If ground screenings are fed to sheep they are injured by the large amounts of "dust" which collects in their nasal passages.

So large has been the amount of screenings in the mills of Minneapolis during the past year or two that the demand has not equaled the supply. Some enterprising millers have adopted the plan of grinding the screenings in bur or roller mills and running this meal through a "reel," separating it into "flour of the screenings" and "cockle bran." This "flour of screenings" is run into the bran or shorts, generally the latter, increasing the output of that higher priced by-product, and the "cockle bran" is sold to local feeders at from two to five dollars per ton. Other mills, as the Pillsbury A, the Minneapolis Mill, and the St. Paul Roller Mill, continue to grind their screenings with roller or bur mills, and sell the meal at about two thirds the price of bran and shorts.

To prevent the shipping of screenings which now accumulate in terminal elevators and in city mills, a far better way than feeding them to sheep in the cities and towns, where the manure is already wasting, or to mix them into the shorts, is for farmers to not "ship the wheat in the dirt." With the improvements now being made in cleaning mills adapted to use on farms and in country elevators there is no excuse for the farmer wasting three or four pounds of screenings per bushel in average wheat by the system of dockage now in vogue. Farmers can, by a little preparation, clean their wheat for considerably less than one cent per bushel, and country elevators, by placing proper machines in their elevators, can clean it for them at less than one-half cent per bushel. Those who grade wheat seem to have so gotten into the habit of counting something "off" for dirt, even if wheat is nearly clean, that shippers are not encouraged to clean their wheat well, while the tendency should be the other way. Screenings vary so greatly in composition (see table I.) and in value that the judgment of the buyer must be exercised in each purchase. The same is true in buying "screenings meal" and "cockle bran."

There is some injustice done buyers by the confusion of names. "Cockle meal" at one mill means excellent ground screenings, from which all coarse

particles of straw and dirt have been sifted before grinding, and the wheat and weed seeds rolled as fine as "rolled oats." By others the same term, "cockle meal," is applied to "cockle bran," one half of which is the black, nearly worthless hulls of wild morning glory seeds, and the remainder partly made up of chaff. Though "cockle bran" contains considerable feed, in the form of wheat bran, it should never be confused with the screenings meal. Putting the "flour of screenings" into shorts or bran slightly decreases the value of these feeds, as is shown by the analyses in tables I. and II. Shorts adulterated in this way can be told by the numerous small black specks, mostly particles of wild buckwheat hulls.

The name *screenings* has been herein used for the waste products cleaned out of wheat, *screenings meal* for the same when ground; *cockle bran* for the bran of small wheat and hulls of weed seeds, after running ground screenings through the "reel" and removing the finer floury particles, which are put into the shorts, and here called *flour of screenings*. These names, as defined, are suggested for use in place of cockle, cockle meal, chicken feed, screenings, and various other names now interchangeably or confusedly used.

TABLE I.—Analyses of Various By-Products of Wheat.

Wheat Screenings Gathered in Elevators and Mills.

	Laboratory Number.	In the air dry substance.							In the perfectly dry substance.				
		Water.	Dry Matter.	Crude Ash.	Ether Extract or Fat.	Crude Fiber.	Crude Protein.	Carbohydrates (by difference.)	Crude Ash.	Ether Extract (Fat).	Crude Fiber.	Crude Protein.	Carbohydrates (by difference.)
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Washburn C. Mill	404	12.75	87.25	2.76	3.25	6.82	8.31	66.11	3.16	3.72	7.84	9.56	75.72
Minn. Transfer Elevator	410	12.28	87.72	3.62	3.32	7.47	12.06	61.25	4.13	3.79	8.52	13.75	69.81
Union Elevator	411	11 79	88.21	1.89	2.66	4.22	9.06	70.38	2.14	3.01	4.77	10.24	79.81
St. Anthony Elevator	412	13.60	86.40	2.16	2.81	1.69	12.44	67.30	2.51	3.24	1.96	14.43	77.86
St. Anthony Elevator	413	11.40	88.60	3.38	3.04	5.66	11.75	63.77	3.82	3.44	6.40	13.28	73.06
St. Anthony Elevator	414	12.61	87.39	2.35	3 04	3.36	15.19	63.45	2.68	3.47	3.83	17.32	72.70
St. Anthony Elevator	415	13.55	86.45	2.13	2.80	3.63	16.88	61.01	2.47	3.25	4.21	19.58	70 49
St. Anthony Elevator	416	12.04	87.96	3.21	2.87	5.45	8.94	67.49	3.66	3.27	6.21	10.19	76.67
Average		12.50	87.50	2.69	3.10	4.76	11.84	65.09	3.07	3.80	5.47	14.79	74.51
Screenings Meal.													
Minneapolis Mill	408	12.58	87.42	3.21	3.75	5.69	6.56	68.21	3.66	4.26	6.49	7.48	78.11
Washburn C. Mill	409	7.32	92.68	2.92	2.75	6.64	8.99	71.38	3.15	2.97	7.17	9.71	77.00
Average		9.95	90.05	3.06	3.25	6.16	7.77	69.79	3.40	3.61	6.83	8.59	77.55
Flour of Screenings													
Washburn C Mill	406	13.32	86.68	2.92	3.12	8.99	9.38	62.27	3.36	3.59	10.34	10.78	71.93
N. W. Roller Mill	417	12.14	87.86	2.92	3.97	3.83	7.25	69.89	3.33	4.52	4.37	8.26	79.52
St. Anthony Roller Mill	419	13.20	86.80	3.19	3.76	3.80	10.19	65.86	3.67	4.32	4.37	11.72	75.92
Average		12.89	87.11	3.01	3.62	5.54	8.94	66.01	3.45	4.14	6.36	10.25	75.79
Shorts.													
N. W. Roller Mill	418	11.31	88.69	4.92	4.80	6.09	14.75	58.13	5.56	5.42	6.88	17.67	64.47
St. Anthony Roller Mill	420	12.15	87.85	4.78	5.62	6.04	16.56	54.85	5.45	6.41	6.89	18.88	62.37
Average		11.73	88.27	4.85	5.21	6.07	15.66	56.49	5.50	5.91	6.89	18.28	63.92
Cockle Bran.													
Washburn C Mill	405	11.37	88.63	3.02	2.81	10.97	9.44	62.39	3.41	3.17	12.40	10.67	70.05
N. W. Roller Mill	444	11.84	88.16	3.09	2.12	9.08	10.50	63.37	3.49	2.40	10.26	11.87	71.98
St. Anthony Roller Mill	445	10.18	89.82	3.55	2.41	7.58	11.92	64.36	3.94	2.68	8.41	13.23	71.74
Average		11.13	88.87	3.22	2.45	9.18	10.62	63.37	3.61	2.75	10.36	11.92	71.26

Since the analysis of screenings and some of the products of screenings herewith given are nearly or quite new, a description made with the aid of a hand magnifying glass is given. The numbers correspond to the laboratory numbers in the table.

SCREENINGS.

404. As run into a bur mill. About one-half cracked and small grains of wheat, one-fourth wild buckwheat, the remainder other weed seeds, principally fox-tail.

410. Three-fifths small wheat, remainder fox-tail and wild buckwheat seeds, straw, etc.

411. One-half very small grains of wheat, other half mostly wild buckwheat, many small weed seeds.

412. Four-fifths is very small grains of wheat, remainder mostly wild buckwheat.

413. Screenings taken from loaded car. One-half small wheat, other half of weed seeds, mainly wild buckwheat; a great quantity of broken pieces of straw and weeds.

415. About four-fifths wheat, some of which is large and of good quality. Remaining one-fifth weed seeds, nearly all wild buckwheat.

416. Screenings from loaded car. Two-fifths small wheat, one-fifth wild buckwheat, remainder chaff, small seeds of weeds and dust.

SCREENINGS MEAL.

408. Screenings meal ground in a bur mill. Quality fair. Numerous fox-tail and other small weed seeds unbroken. A few seeds as large as wild buckwheat passed through the mill unbroken.

409. Screenings meal as run through a bur mill preparatory to separating it into "flour of screenings" and "cockle bran." Wild buckwheat seeds all broken, but numerous fox-tail and other small seeds unbroken.

FLOUR OF SCREENINGS.

406. Flour of screenings as it ran into the shorts after cockle bran is "reeled" out of it. It was estimated that this increases the out-put of shorts about 10 per cent., but that is probably much too low. Much darker than shorts, owing to the great number of particles of wild buckwheat hulls contained.

417. Flour of Screenings as it went into the shorts, mainly granular particles of wheat and weed seeds. Many particles of black hulls of wild buckwheat.

SHORTS.

418. Shorts before "flour of screenings" went into it. Mainly fine wheat bran, a small amount of granular particles of wheat.

420. Shorts before "flour of screenings" entered. Rather fine bran with medium amount of granular and floury particles.

COCKLE BRAN.

405. Cockle bran, one-half is the hulls of wild buckwheat, remainder bran of wheat, chaff, etc. Sells at $2.00 per ton and well worth that money.

444. Cockle bran, half hulls of wild buckwheat. Some chaff and dirt but most of remaining half is wheat bran.

445. Cockle bran ground in roller mill—weed seeds all broken—about two-fifths each of wheat bran and wild buckwheat hulls, remaining one-fifth chaff and hulls of weed seeds.

VALUE OF SCREENINGS AS A FEED.

Wheat screenings vary widely in composition. In some cases they are mainly light grains of wheat, No. 415 in Table I., for instance, which our previous analyses show to have a greater market value for feeding than good wheat, on account of the greater per cent of protein (See page 77 *et seq*, also table on page 81 in Bulletin No. 7). In other cases screenings are particles of straw, chaff, immature fox-tail seeds and other like materials. In the following table are given the average analysis of screenings and screenings meal of ten analyses herein reported and two by Prof. R. C. Kedzie, recently reported in a bulletin of the Michigan Experiment Station. The average analysis of flour of screenings and cockle bran are also from our analyses, while those of oats, clover, hay, shorts and bran, are from Dr. Jenkins' table of average analyses of feeding stuffs in the Connecticut station reports for 1888.

TABLE II.—AVERAGE COMPOSITION OF WHEAT SCREENINGS, FLOUR OF SCREENINGS AND COCKLE BRAN, AS COMPARED WITH OATS, SHORTS, BRAN AND CLOVER HAY.

	Dry Matter	Ash	Crude Fiber.	Crude Protein.	Ether Extract-fat	Nitrogen Free Ext't
	per cent.	*per cent.*	*per cent.*	*per cent.*	*per cent.*	*per cent.*
Oats	89.06	2.97	9.85	11.38	4.81	60.05
Screenings	88.99	2.93	5.12	11.67	3.00	65.83
Flour of Screenings	87.11	3.01	5.59	8.94	3.62	66.01
Cockle Bran	88.87	3.22	9.18	10.62	2.45	63.37
Clover Hay	88.62	6.23	26.85	12.55	2.44	40.55
Shorts	87.26	4.25	7.45	13.83	3.83	53.50
Bran	87.62	5.59	9.34	15.36	4.14	57.59

As will be observed in the table, the composition of an average sample of screenings differs but little from that of oats, and practical experience indicates that good average screenings have nearly an equal feeding value for many purposes. The flour of screenings is shown to have considerable less of protein (muscle formers) than shorts, and therefore adding it to the shorts slightly decreases the value of the shorts for mixing with coarse rough fodders which need to be supplemented with feeds especially rich in protein. Our estimation of screenings has increased constantly since this investigation was begun, and we cannot too strongly urge our farmers to value the waste in the wheat, upon which they now pay freights to market, at its true worth, as demonstrated by the figures and facts herein presented. Even the better grades of cockle bran, owing to a large proportion of wheat bran contained, have a value approaching that of hay, as is shown by chemical analysis (see Table II.), and as is attested by numerous dairymen and farmers in this vicinity who feed it in large quantities. These products should all be fed in the country producing the wheat, because of their value in feeding animals, and for fertilizing the land.

A future report on methods of screening wheat on the farm and in country elevators is contemplated.

THE ROCKY-MOUNTAIN LOCUST IN OTTERTAIL COUNTY, MINNESOTA, IN 1889.

The invasion by this injurious insect in 1888, as well as the damage done by it, and the various means employed against it in that year, have been described in previous bulletins, and in the last Annual Report. Last summer about 35,000 bushels of "hoppers" were killed by various means and contrivances, yet large numbers of more or less healthy insects escaped to deposit their eggs for another generation. Late in August, 1888, I inspected the fields near Perham, and found but few egg-masses in the soil, and these quite small, clearly indicating a lack of vigor in the parent insects. Large numbers of parasites were also detected in the work of destroying the eggs. The same good news was reported by Mr. A. C. Hatch, who inspected the region about Battle Lake and vicinity. At that date numerous winged locusts were still at large, moving about in larger or smaller swarms. Such swarms were badly scattered, both on account of having been constantly disturbed by the "balloon catchers," but still more so by the severe frost, which had killed a very large proportion of the vegetation, thus forcing the hungry insects to wander about in search of food. These surviving insects were almost entirely free from parasites, and consequently strong and healthy. These deposited the eggs for the generation of 1889. As has been explained in the Annual Report, the parasites, and chiefly the Red Mite, although exceedingly numerous in 1888, had—owing to the peculiar weather of that year—only succeeded in fastening to those hoppers, which matured first, or rather to those which first offered a projection as wing pads making this possible.

Early in April, 1889, the inhabitants of the infested region in Ottertail County, appealed to His Excellency Governor W. R. Merriam, for assistance in destroying the locusts, which were expected to hatch from the eggs deposited in August and early September of the previous year. During the session of 1888-1889, the legislature of Minnesota had been appealed to for the necessary means to prosecute this work, and a sum of money for this purpose was appropriated. As the governor was both very anxious to assist the suffering farmers in the invaded region, and to prevent another devastation by these insects, he requested Capt. O. C. Chase, the intelligent chairman of the county commissioners of Ottertail county, and myself, to proceed to Perham, and to adopt and carry out the necessary means to exterminate, if possible, this insect pest. The board of regents of the University, knowing the importance of prompt action in this matter, kindly permitted me to spend all the time necessary in this work. The Northern Pacific Railroad Company again liberally granted free transportation for

kerosene oil, coal tar, etc., and furnished me also with transportation. On April 17, Captain Chase and myself met in Perham to inspect the fields infested by locusts, and to devise means to prevent further injuries.

RESULT OF THE INSPECTION.

The observations and experiences of last year plainly indicated the method best adapted for our purpose. As already stated in the Annual Report for 1888, no locusts had issued in that year from eggs in fields plowed after such eggs had been deposited. To make quite sure of the correctness of this observation, numerous plowed fields were investigated very closely, but in no case could a single egg-mass be found near the surface, which was so much hardened and compressed by the snow and rain of winter and early spring, that no young and still soft insects could possibly penetrate through it and reach the surface. Subsequent observations also showed that no locusts hatched from such fields. Only in one case many eggs were discovered in a field seeded with wheat, and large numbers of young locusts hatched and reached the surface. Upon investigation it was found that this field had not been plowed late in the fall or in the spring, but had been simply harrowed very shallow to cover the seed; it was further found, that no crop had been raised the previous year, the land having been merely plowed once during early summer as a sort of summer fallowing. The eggs of the locusts were consequently not disturbed at all, or but very slightly so. This field was condemned and the wheat had to be plowed under, and with it all the young locusts, before they could spread to adjoining fields. A large portion of the infested region had been plowed and put to crops, and therefore contained no eggs near the surface. But another large portion of cultivated land had been abandoned, or had not been plowed in the fall of 1888, the owners being afraid of again losing the fruit of their labors. Such neglected or abandoned fields were found everywhere scattered among fields that had been plowed and seeded. Two kinds of neglected fields occurred everywhere; some were simply covered with last year's stubble, others with that of previous years and the remains of a rank vegetation of weeds. A close inspection soon revealed the fact that fields with last year's stubble contained large numbers of eggs, whilst stubble land of 1887 and older contained none, or but very few. This observation simplified the work very greatly, as thus the area to be plowed became smaller and manageable. Careful investigation of other fields showed some eggs in the denuded spots of timothy fields, but mainly near their edges. Wherever the timothy plants covered the ground entirely, no eggs could be detected. A similar observation was made in pastures; if well sodded, no eggs; if bare of vegetation, a few could be detected. Nor were eggs found in very old stubble-land, which was well covered with pigeon-grass. This was plainly due to the fine and numerous roots of this grass, which grow very near to the surface, and thus mechanically prevent the female locusts from drilling a hole in the ground for the reception of her eggs. No eggs could be found in the native prairie land, and but a few along roads and the elevated bed of railroads. Of course the finding of eggs did not always give a clear idea as to their numbers in any given field;

it even so happened, that one inspection in many places of a suspected field might not reveal any eggs at all, while a second one, at some other time, would show a fairly large number. Evidently the maternal instinct of the locust directed all her movements, and certain and definite places were selected for oviposition. As the ground in a large portion of the infested region is almost level, it was at first somewhat difficult for us to judge where the best conditions for egg-laying might have prevailed last fall, but before long our eyes became so practiced that we could tell at a glance where eggs would most likely be found. It is difficult to describe such spots preferred by the female locusts for laying their eggs, but as a rule they were found in little ridges, or in spots quite free from roots.

AREA IN WHICH EGGS OF LOCUSTS WERE FOUND.

Investigations in the infested region soon showed that essentially the same area contained eggs as in 1888. Only a slight progress towards the northwest could be established. Evidently the locusts of last year had not spread over a larger space, but had held their ground in spite of the loss of many that had been killed by both natural and artificial means. The map upon following page was prepared from notes made by Capt. Chase. It shows the infested region of Ottertail County, as well as the fields plowed at the expense of the State; these appear black in the map.

CONDITION OF THE EGGS.

As already stated, all the egg-pods were quite small, containing only occasionally the normal number of eggs. In many cases only from eight to fourteen could be counted, and egg-masses with even fewer eggs were not uncommon. In the newly invaded regions, and chiefly towards Frazee City, the egg-masses were of the normal size, showing that only the healthiest locusts had been able to travel that far.

In some fields seventy-five per cent. and even a larger percentage of eggs had been destroyed by parasites, and quite a number of these useful insects were found still at work. In other fields about fifty per cent. were eaten by such parasites. Considering the whole area infested by locusts, it is quite safe to say that at least one-half of all the eggs had been destroyed by one cause or another, but principally by egg-feeding insects.

The great majority of the eggs showed upon close study, that they were perfectly healthy. Some that were taken last fall from the vicinity of Perham, and kept at this Experimental Station in a warm room, hatched on December 25 and January 7. The eggs, freshly taken from the fields, showed in some cases that the embryon within was just forming, and in some cases the eyes could be clearly discerned below the egg-shell, showing that at least some of the eggs would hatch early in May. Many eggs were reported as having already been hatched in some localities, but investigation always showed that such insects were the young of native species. Nor were the reports of the appearance of larger locusts correct, as these were also native species, which had hibernated in their pupal stage.

HOW THE EGGS ARE LAID.

In my report of 1888, considerable stress was laid upon the manner and location in which eggs are laid by the Rocky-Mountain Locusts and allied

species. As the remedy applied this year depends almost entirely upon this, I deem it important to repeat and enlarge upon what was written at that time. The following figures 1, 2, 3 and 4, will illustrate this point better than words. The holes for the reception of the eggs are made by means of two pairs of horny valves at the tip of the abdomen of the female (Fig. 1, b and c). These open and shut rapidly, and are well adapted to execute this function. The female pressing the tip of her abdomen forcibly against the soil, rapidly opens and shuts these hard and pointed valves, and soon pushes them into the ground, thus drilling a hole. Fig. 2 illustrates this action, and the various positions assumed by the female are plainly indicated. In a short time nearly the entire and greatly extended abdomen is inserted in a little curved and more or less oblique cavity. The legs are hoisted above the back during the operation of drilling this hole, which requires more or less time, depending entirely upon the condition and character of the soil. As soon as the hole is finished, it is filled with a frothy and mucous material. Professor Riley, in describing the method of laying eggs, writes: "By repeatedly extricating and studying specimens in every possible stage of oviposition, we have been able to ascertain the exact method by which the egg-mass is formed. If we could manage to watch a female from the time the bottom of her hole is moistened by the sebific fluid, we should see the valves all brought together, when an egg would pass down the oviduct

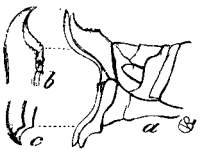


Fig. 1.—Rocky-Mountain Locust — Anal characters of female, showing horny valves. (After Riley.)

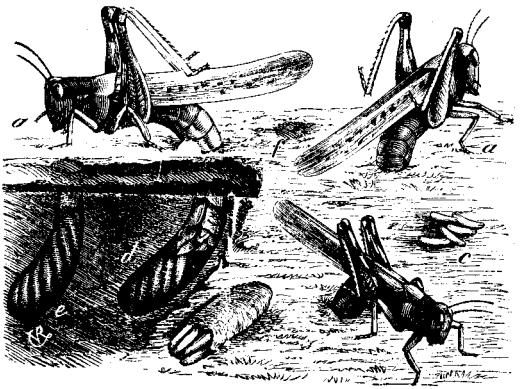


Fig. 2.—Rocky-Mountain Locust—*a, a, a,* female in different positions, ovipositing; *b,* egg-pod extracted from ground, with the end broken open; *c,* a few eggs lying loose on the ground; *d, e,* show the earth partially removed, to illustrate an egg-mass already in place, and one being placed; *f,* shows where such a mass has been covered up. (After Riley.)

along the ventral side, and, guided by a little finger-like style pass in between the horny valves, and issue at their tips amid the mucous fluid already spoken of. Then follows a period of convulsions during which more mucous material is elaborated, uutil the whole end of the body is bathed in it, when another egg passes down and is placed in position. These alternate processes continue until the full complement of eggs are in

place, the number ranging from twenty to thirty-five, but averaging about twenty-eight. The mucous matter binds all the eggs in a mass, and when the last is laid, the mother devotes some time to filling up the somewhat narrower neck of the burrow with a compact and cellulose mass of the same material, which, though light and easily penetrated, is more or less impervious to water, and forms a very excellent protection. When fresh the mass is soft and moist, but it soon acquires a firm consistency.

To the casual observer, the eggs of our locust appear to be thrust indiscriminately into the hole made for their reception. A more careful study of the egg-mass, or egg-pod, will show, however, that the female took great pains to arrange them, not only so as to economize as much space as possible, consistent with the form of each egg, but so as to best facilitate the escape of the young locust; for if, from whatever cause, the upper eggs should fail to hatch, or should hatch later than the lower ones, the former would offer an impediment to the exit of the young in their endeavors to

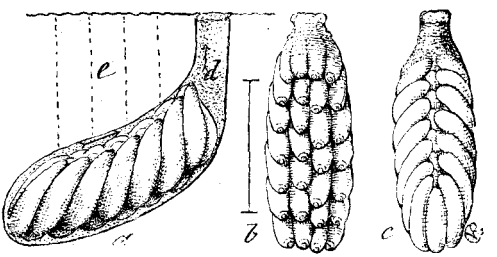


Fig. 3.—Egg-mass of Rocky-Mountain Locust—*a*, from the side, within burrow; *b*, from beneath; *c*, from above, enlarged. (After Riley.)

escape from these last, were there no provision against such a possibility. The eggs are, indeed, most carefully placed side by side in four rows, each row generally containing seven. They oblique a little crosswise of the cylinder (Fig. 3, a). The posterior or narrow end, which issues first from the oviduct, is thickened, and generally shows two pale rings around the darker tip (Fig. 3, b). This is pushed close against the bottom of the burrow, which, being cylindrical, does not permit the outer or two side rows to be pushed quite as far down as the two inner rows, and for the very same reason the upper or head ends of the outer rows are necessarily bent to the same extent over the inner rows, the eggs when laid being somewhat soft and plastic. There is, consequently, an irregular channel along the top of the mass (Fig. 3, c), which is filled only with the same frothy matter that surrounds each egg, which matter occupies all the other space in the burrow not occupied by the eggs. The whole plan is seen at once by a reference to the accompanying figure, which represents, enlarged, a side view of the mass within the burrow (a), and a bottom (b) and top (c) view of the same, with the earth which adheres to it removed."

Each female of the Rocky-Mountain Locust lays on an average about three egg-masses; this is done at intervals of two weeks, so that the egg-laying season extends from six to eight weeks.

The egg is surrounded by a shell consisting of two layers, of which the outer one is thin, semi-opaque, thus producing the cream-yellow color; highly magnified it appears (Fig. 4, a) densely and minutely pitted, or rather netted with minute and hexagonal ridges (Fig. 4, b). The inner and thicker layer is deep yellow, smooth and translucent, so that the form of the embryon can be plainly seen when maturing inside. The outer layer is quite brittle, but the inner one very tough, requiring a strong pressure to rupture it. As the embryon within matures, the egg-shell becomes weakened, and the egg plump and somewhat more transparent. By the muscular efforts of the enclosed insect, but chiefly by the thorns arming the hind tibiæ, the shell is eventually broken, and the young locust pushes its way through the neck of the burrow towards the light.

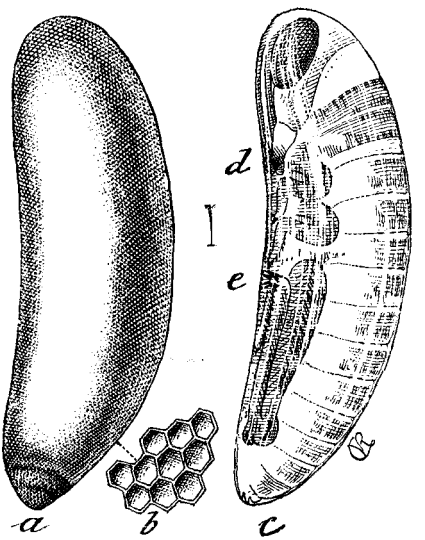


Fig. 4.—Egg of Rocky-Mountain Locust—*a*, showing sculpture of outer shell: *b*, the same very highly magnified; *c*, the embryo, just before hatching. (After Riley.)

Nearly always all the eggs in a pod hatch at the same time, and the young escape through the small hole left for this purpose. When the young insects reach the surface they are quite weak, and still surrounded by a very delicate film, which has to be first removed before the young locust can jump about. By contracting and expanding muscular movements this enveloping film splits along the middle of the back, near the head, and is gradually pushed backwards, remaining as a white crumpled pellet behind. At first, pale and colorless, the young locust assumes its dark color in the course of an hour.

"From this account of the hatching process, we can readily understand why the female in ovipositing prefers compact or hard soil to that which is loose. The harder and less yielding the walls of the burrow, the easier will the young locust crowd its way out.

Though the covering which envelops the little animal when first it issues from the egg is quite delicate, it nevertheless, in the struggles of birth, undoubtedly affords much protection, and it is an interesting fact that while, as we have just seen, it is shed within a few minutes of the time when the animal reaches the free air, it is seldom shed, if, from one cause or other, there is a failure to escape from the soil, even though the young locust may be struggling for days to effect an escape.

While yet enveloped in this pellicle, the animal possesses great forcing and pushing power, and if the soil be not too compact, will frequently force a direct passage through the same to the surface, as indicated at the dotted lines (Fig. 3, e). But if the soil is at all compressed it can make little or no headway, except through the appropriate channel (Fig. 3, d). While crowding its way out, the autennæ and four front legs are held in much the same position as within the egg, the hind legs being generally stretched. But the members bend in every conceivable way and where several are endeavoring to work through any particular passage, the amount of squeezing and crowding they will endure is something remarkable. Yet if by chance the protecting pellicle is worked off before issuing from the ground, the animal loses all power of further forcing its way out. The instinctive tendency to push upwards is also remarkable. In glass tubes, in which I had the eggs hatching in order to watch the young, these last would always turn their heads and push towards the bottom whenever the tubes were turned mouth downwards; while in tin boxes, where the eggs were placed at different depths in the ground, the young never descended, even when they were unable to ascend on account of the compactness of the soil above."

The above minute account of the manner in which eggs are laid, and how the young insects are enabled to reach the surface, plainly indicates one good method by which the hatching of the eggs may either be prevented entirely, or by which the young will be prevented from reaching the surface. By plowing the fields containing eggs of the Rocky-Mountain Locust, we perform two operations: We first of all remove the eggs from the surface, and cover them with five or six inches of soil; secondly, we invert the position of the hole containing the egg-mass, so that instead of its mouth pointing upwards, it now points downwards. At all events, the young insects are prevented from reaching the surface, if this becomes compact by rain and snow. Consequently, if we plow during autumn, or soon after the eggs are laid, we are safe; although if we plow in the spring with the normal amount of rain, we also effectually prevent their hatching and their escape. Plowing has this additional advantage: the egg-masses in most cases are thoroughly broken up, the individual eggs become surrounded by earth and moisture, and being no longer protected by the waterproof coat of dried mucous matter, they soon rot and perish.

EXPERIMENTS MADE WITH EGGS.

Since the method employed to kill the locusts depended almost entirely upon the question: Can the young insects reach the surface of plowed fields or not? I deemed it very important to carry out some experiments at

the station, to enable me to give a positive reply to that question. During my first trip to Perham, early in April, I collected large numbers of eggs, both for experiments, and to breed certain parasites from them. These eggs were planted at different depths in flower-pots, which contained a soil similar to the one from which the eggs were removed. The result of these experiments may be learned from the table given below:

SOIL KEPT DRY.

Eggs planted	1	inch	below	surface	produced	93	per	cent.	of	locusts.
"	"	2	"	"	"	"	86	"	"	"	"
"	"	3	"	"	"	"	51	"	"	"	"
"	"	4	"	"	"	"	13	"	"	"	"
"	"	5	"	"	"	"	02	"	"	"	"
"	"	6	"	"	"	"	none.				

SOIL MOISTENED FROM TIME TO TIME.

Eggs planted	1	inch	below	surface	produced	87	per	cent.	of	locusts.
"	"	2	"	"	"	"	43	"	"	"	"
"	"	3	"	"	"	"	11	"	"	"	"
"	"	4	"	"	"	"	01	"	"	"	"
"	"	5	"	"	"	"	none.				
"	"	6	"	"	"	"	none.				

All the eggs experimented with were in pods, which were in no way injured or broken.

To guard against any lateral movements of the young locusts, and to prevent them from reaching the surface of the soil near the walls of the pots, where cracks would naturally form by contraction, the surface of this part of the soil was covered with a tight-fitting ring of cardboard. All the eggs were carefully planted in the center of the soil. Lifting up this ring later, many locusts were found under it, showing that they had tried hard to reach the surface by digging in a horizontal direction towards the least compressed soil.

One thousand eggs, either single ones or in twos or threes, but all free from any mucous covering, were planted one inch and a half deep. The soil above them was gently compressed, and kept moist. Only 103 young hoppers managed to reach the surface. As this happened while away from the station I am not certain whether or not some of them came from below the ring of cardboard near the inside of the flower-pot, this board having warped considerably on account of the moisture of the soil.

Early in July, after all the experiments had been finished, the soil from the various flower-pots was thrown into a large box, and was thoroughly loosened with the fingers. In consequence of this, seven young locusts made their appearance, showing that some of the eggs, or of the young insects, had retained their vitality up to that time.

The following is a translation from an article published in the *Fergus Falls Ugeblad:*

Mr. John Ledel made a number of experiments with the eggs and young of the Rocky-Mountain Locusts. He wanted to know if locusts could live in the ground for a short time, and whether they would be able to reach the surface of the soil. He put a number of such insects just hatched in a tin can, covered them up with about one inch of soil, and put them

away. When he examined the can again, three or four days later, they were all dead. He feels now convinced that they can not live in the ground, nor make their way to the surface, if covered with soil to the depth of a plow-furrow.

MEANS EMPLOYED TO KILL THE LOCUSTS.

PLOWING.—The chief method employed to prevent another locust season consisted in plowing the fields known to contain eggs. By carefully investigating the suspected fields in numerous places, an approximate knowledge could be gained as to the number of eggs they contained. Having found that last year's stubble harbored the greatest number, all such fields found to be badly infested were condemned. It would have been impossible to plow them all in time to prevent the eggs from hatching. It was learned from a close study that most of the eggs would hatch before the middle of May, which gave us only five weeks time in which to operate. We therefore concluded to plow first of all the most dangerous places, and immediately those in close vicinity of cultivated farms. Farmers who had shown enough energy to risk another crop, assuredly well deserved to be first protected. Nor did we condemn any fields smaller than twenty acres, as we thought the owners of such small fields could well afford to plow them in self-protection. Of course, no land intended to be used for corn, even if containing eggs, was plowed at the expense of the State, as we knew it would be plowed anyway. Such rules could not in all cases be followed closely, as the conditions varied greatly in different localities, but we tried to make them our guide. The land condemned had to be plowed five to six inches deep to entitle the laborer to draw his pay, which was $1.25 per acre. As soon as a field was ascertained to contain a dangerous number of eggs, it was condemned, and farmers living in the vicinity were invited to plow it within a given time. If possible the owner of the land was requested to see that the work was done thoroughly, he being the person most interested to have the locusts killed; nothing was paid for his supervision of the work.

To encourage the farmers, and to obtain some returns for the money expended by the State, the owners of land plowed at the expense of the State were requested to seed the land with oats, flax, barley, or any other crop. Many persons made good use of this opportunity, and will raise paying crops; others had not the means or courage to do so, and are now quite sorry for having lost such an opportunity. The seeding of such plowed land also had the tendency to make its surface more compact, and consequently safe against hatching of the eggs.

Gradually, and before any locusts had hatched, the fields worst infested were thus plowed. Now the less dangerous fields were operated upon, and also some badly infested timothy fields and pastures. But it would have been impossible to plow all the timothy fields, even those known to contain eggs, as the farmers would have been left without any hay for their stock. To destroy as many eggs as possible, and to save the adjoining fields of wheat, we isolated such timothy fields, by plowing a strip two or three rods wide around them, thus creating a neutral zone upon which hopperdozers could be used later, if necessary.

Plowing proved a great success. Notwithstanding the fact that everything, as far as natural conditions were concerned, was in favor of the locusts, none hatched in the plowed fields. The soil in the infested region is very light and sandy, and as no rain fell during the operation of plowing, it was also very loose. Yet numerous and very searching examinations failed to show young locusts in the plowed fields, nor were any reported as being hatched, plainly proving that a covering with five or six inches of soil prevented the young hoppers from making their way towards the surface. Plowing, although it would break and open many egg-pods, does not destroy the vitality of the eggs. But the soft insects, even if enabled to issue from the enclosing egg-shells, have neither the strength nor the ability to force their way to the light of day, and perish in the attempt to do so. A good illustration happened in the case of one who was mean and stupid enough to forbid the plowing of his mortgaged land at the expense of the State. He evidently wanted to be paid for (as was the practice last year) catching full-grown locusts and thus make more money than he could make by honestly plowing his own land. All the adjoining land was condemned and plowed, being full of eggs, and no locusts hatched there, while in his field multitudes of them appeared, which, owing to the lack of food, were forced to move into the wheat fields of his neighbors, greatly damaging their crops. There is no law compelling a man of this kind to do his duties to his neighbors and to the State. The plowing of his neglected fields would not have cost him one cent, but would have been of the greatest benefit to the whole community; yet this very man, who had been paid by the State some $400 in 1888, stupidly if not maliciously prevented the killing of our common enemy, the Rocky-Mountain Locust. As a general rule, nearly all the people in the infested region, with commendable diligence worked hard and faithfully to get rid of their common enemy. Of course, in such an extended region, the plowing could not all be watched, and some land was plowed rather poorly. But even upon such land but few locusts appeared above ground, and they, as a general rule, starved before they could reach any food in the unplowed fields. As not all the fields could be inspected in time for eggs, a large number of young locusts hatched in some of them before we could reach them. In all such cases, plowing proved also a perfect remedy. Such a field was either divided in small lots, all of which were plowed immediately, or a number of plows followed each other as closely as possible, in either case commencing operation at the outer edges of the field. A black mass of struggling hoppers gradually crowded together towards the center. But few escaped from being buried alive; as one plow made a furrow, it rapidly filled with hoppers, and the following plow would readily cover them up. Only near the edges some of the young locusts escaped, and those that were not buried starved before reaching feeding grounds. As we commenced in time, plowing was everywhere a complete success. The area infested being quite large, we had to divide the work, and Mr. A. C. Hatch took charge of it near Battle Lake, Mr. W. D. Hunter near Ottertail, and Captain Chase and myself near Perham.

BURNING.—In many places, where the eggs were not numerous enough to warrant plowing, all the old stubble and dead grass was preserved until

the young locusts appeared. After plowing around such fields to prevent the escape of the fire, the whole enclosed space was burned over, and untold numbers of locusts thus perished.

CATCHING BY MEANS OF HOPPER-DOZERS.—Meanwhile the hoppers from timothy fields and pastures were hatched, and threatened destruction to neighboring wheat fields. But as we had kerosene-oil, coal-tar and hopper-dozers ready at hand, farmers were quite willing to work upon their farms to kill off the enemy. They well knew that there was now no danger of an invasion of hoppers raised in neglected or abandoned fields in their vicinity, and all they had to do was to kill the insects raised upon their own land. They very soon succeeded in entirely checking and exterminating them, and so saved their crops. But there were a few localities in which large tracts of old timothy fields and pastures belonging to non-residents, or to people too stingy to expend any money or labor in killing the locusts. In such cases we had to protect the more deserving farmers, and had to hire persons to catch and kill the hoppers by means of hopper-dozers, which did the work most thoroughly and successfuliy. In fact, a careful use of this practical contrivance will soon destroy a very great majority of such insects. To catch as many locusts as possible with the least expense for labor, four hopper-dozers were joined together by means of short ropes, thus forming a continuous pan some forty feet long. Fig. 5 shows a single hopper-dozer.

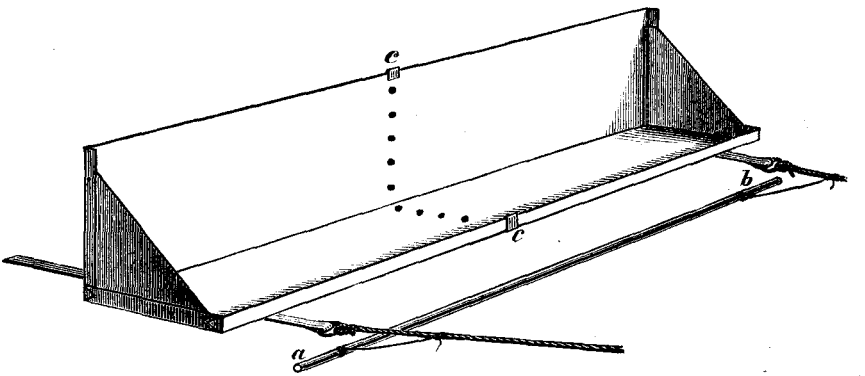


Fig. 5.—Small Hopper-dozer.—(After Riley.)

The pulling ropes from the corners of each pan were left rather long, and fastened to a singletree; the combined weight of these dozers could be easily drawn by one horse, which, moving in the front of the center, scared the locusts and made them jump. To stir them up still more a rope was dragged some few inches in front of the dozers, and the locusts in jumping all landed in the pan, which had also a canvas stretched behind it to deflect too active hoppers, and throw them into the oil. As the farmers liked a mixture of coal-tar and kerosene-oil, better than the latter alone, because they could actually see their enemy perish before their eyes, these materials were furnished them free of expense. The farmers were not paid for labor in their own fields.

ROLLING.—In several instances farmers tried to kill the young locusts by means of very heavy rollers, but without any success whatever. The ground was so loose and dry that, notwithstanding the fact that the roller would press down the surface of the soil to a depth of almost two inches, no hoppers were injured. They would be as lively again after the pressure had ceased as they were before this operation. Even the horses, stepping upon the young insects, would not kill them in every case, plainly indicating that under the conditions prevailing at the time, rolling would be mere waste of time and labor.

LONDON PURPLE.—This material was used in several cases with marked success, and would have been used much more extensively if farmers had not been afraid of killing their stock. In one case a farmer had refused to plow pasture land full of the eggs of the locust. As soon as the young locusts appeared above the surface, they were driven from the pasture by the grazing animals, and by a strong wind blowing from the same point of the compass for several days. The insects soon found their way into an adjoining field of wheat. A trench was plowed close to the fence surrounding the infested pasture, to prevent the enclosed animals from reaching the wheat plants, which were dusted over with London purple. In a few days not one locust remained, and the field was perfectly free of them.

NEEDED LEGISLATION.

About the middle of June it became quite plain that the crops were saved, and that most of the locusts had been killed. This ought to demonstrate to the inhabitants in the infested region that plowing is the true remedy, and that it is their fault if invasions of such a local character are not made to terminate within a year. If all the land under culture had been plowed, this local trouble with locusts would have come to an end some years ago. At all events, farmers now see that only the unplowed and neglected parts of their farms can breed the enemy. I wish again to draw the attention of the legislature to the fact that a law is badly needed in this State to force people in locust-affected regions to plow all those fields that are known to contain the eggs of this insect. It would be best to plow the fields late in the fall, after the eggs have been laid, or early in the spring, so that the surface of the land might become solid and impenetrable for soft locusts. Land deserted by its owner, or held by speculators, and known to contain eggs of the Rocky-Mountain Locusts, should be caused by the county commissioners in the infested county to be plowed, or by the town board of supervisors. Locusts should be considered as a public menace, and should be treated as such. This view of the case would enable those in charge of such affairs to plow infested fields, or catch the hoppers upon them, even against the will of their owners. As it is now, a single stupid or obstinate man can raise enough locusts upon his fields to endanger the crops of the whole neighborhood, and perpetuate the species in that region.

EXPENSES OF EXTERMINATING THE LOCUSTS IN 1889.

Captain O. C. Chaise has kindly furnished the following statement:

6361.59 Acres plowed at $1.25 per acre	$	7,951 98
Expenses for material		543 11
Expenses for labor		1,635 91
	$	10,131 00

INVESTIGATION OF FIELDS IN JULY.

Being very important, and also quite interesting in many ways, some of the soil in fields known to contain numerous eggs was carefully investigated two months after having been plowed. Although it was not an easy matter to detect egg-pods at the depth of five or six inches, many were found, some entire, others broken. In every instance not a single healthy egg could be detected. If still enclosed by the mucous envelope all the eggs were rotten;* if detached, they were either rotten or had shrivelled up. This condition depended, of course, upon the greater or smaller amount of moisture in the soil. In many cases the eggs had hatched, and the corpse of the young locusts, enveloped by a thin and white shroud, was found in close proximity.

PARASITIC AND CARNIVOROUS INSECTS.

All the parasites and carnivorous insects and animals mentioned in the Annual Report for 1888, were equally abundant this year. The Red Mite (*Trombidium locustarum*) occurred in such vast numbers in some fields as to give a distinct red color to the soil, and large numbers of them were found still snugly hidden in the egg-pods of the locusts, engaged in feeding upon the eggs. Nor did the plowing of the infested fields destroy very large numbers of them, so that most of the mites, owing to their smallness and the looseness of the soil, succeeded in making their escape to the surface, ready to again help us against the invader. Early in July their six-legged young had already commenced to fasten themselves to the semi-pupæ and pupæ of the locust, and no doubt they will again do good service in reducing the health of their hosts and of other insects.

Immense numbers of the larvæ of the Bee-fly (*Syntœchus oreas*) were found everywhere in the ground, but most commonly inside the empty egg-pod of the locust, or at least in close proximity to it. These white larvæ, curled up and almost motionless, must have been quite active in their earlier stage, to succeed so well in finding such eggs; thus far their early history has escaped all observation, and is still hidden in mystery. Next to the Red Mite they have been of greatest importance in checking the increase of our enemy.

The larvæ and pupæ of a number of Blister-beetles occurred everywhere, and later large numbers of the winged insects could be found.

Quite a number of eggs of the locusts had been destroyed by a true parasitic insect, similar to the one illustrated below (Fig. 6 *a*). It is a new

* From the *Fergus Falls Ugeblad*, June 19, 1889: In several places, where the eggs were most thickly deposited, we dug in the plowed ground to ascertain in what condition the eggs were. We found them all dead and shrivelled.

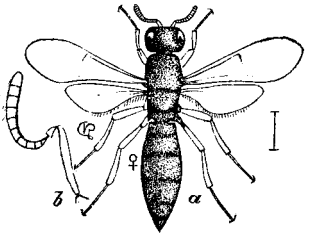


Fig. 6.—*Scelio*—*a*, female; *b*, her antenna. (After Riley.)

species of *Scelio*. In some egg-pods every egg was eaten by the larvæ of this useful insect, so that instead of harboring an embryon of a locust, it contained a small wasp. These minute insects are difficult to find, as they are not distinguished by metalic colors, which is usually the case, but are of a dingy black color, with honey-yellow legs. Moreover, they do not fly about actively, but rather crawl over the soil. If disturbed, they jump like fleas and vanish from sight. I raised a number of them in breeding cages from eggs of the locusts, and consequently am certain that those captured in the fields are really the species breeding in the eggs.

In addition to such insects mentioned in the Annual Report for 1888, I found very numerous larvæ of egg-feeding beetles, chiefly of ground-beetles. The most important ones belong to the genus *Amara*. In some fields every second egg-pod contained the larva of *Amara latior* Kirby; if not actually inside the egg-pod, it was found upon the outside of it or very close to it. Numerous larvæ of a larger species (*Amara obesa Say*) were also found, and by keeping them confined in breeding cages the mature insects would soon emerge. The illustration below (Fig. 7,) will serve to show the appearance of these carnivorous larvæ.

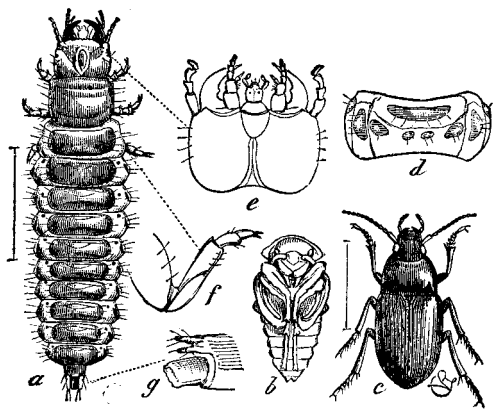


Fig. 7.—*Amara obesa* Say.—*a*, larva; *d*, under side of one of its middle joints; *e*, its head beneath; *f*, its leg: *g*, its anal cerci and pro-leg from side; *b*, pupa; *c*, beetle. (After Riley.)

Another larva was also quite abundant, but was not reared to its perfect state; it is illustrated in Fig. 8. Prof. Riley believes it to be the larva of *Harpalus herbivagus* Say, an insect very abundant in the locust infested region.

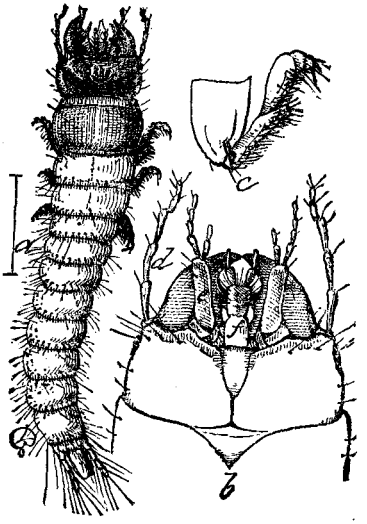


Fig. 8.—*Harpalus?*—*a*, larva from above: *b*, head, from beneath; *c*, leg, enlarged. (After Riley.)

A very interesting larva occurred in some numbers, each usually snugly hidden in the inside of an egg-pod. It is illustrated in Fig. 9. Although rather common, I only succeeded in rearing one of the mature beetles, which proves to be a Click-beetle (*Cryptohypnus bicolor Esch., var. lacustris*).

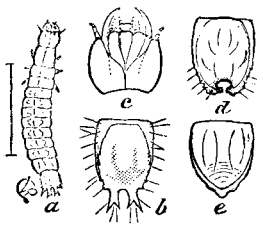


Fig. 9.—*Cryptohypnus bicolor Esch*—*a*, larva from above; *c*, head from beneath; *b*, anal joint from above; *d*, *e*, anal joints of other species with the same habit. (After Riley).

Numerous larvæ of flies occurred near the egg-masses, but I can not be sure that they are in reality friends, with the exception of an asilid larva, which transformed into a Hawk-fly (*Erax bastardii*), well known by its habit of pouncing upon all sorts of winged insects. The same insect, as well as a larger species, is very fond of young locusts; it would pounce with amazing speed upon its prey, and carry it away to some distance, sucking out its life blood by means of its powerful beak. Tachina flies and Flesh flies, as well as a number of smaller species, occurred in vast numbers wherever locusts had deposited their eggs; they, or their larvæ, had no doubt found such eggs to their taste.

OTHER SPECIES OF LOCUSTS.

Evidently the same climatic conditions favoring the existence of the Rocky-Mountain Locusts have been the cause of the rapid and exceptional increase of numerous other and similar species. During the early summer at least twenty species of locusts occurred in large numbers throughout Ottertail county and elsewhere. In fact, many of the eggs plowed under,

and of the young locusts killed otherwise, belonged to some of these native species. But as they were found in bad company they had to suffer with the real culprit. During the early part of the month of July, when called hither and thither to investigate reported outbreaks of the locust plague in unexpected regions, it was found that farmers had mistaken some native species for the real Rocky-Mountain Locust. To enlighten them the two plates at the end of the article have been copied from the lithographic illustrations published in the first report of the United States Entomological Commission. The first plate shows all the different stages of the Rocky-Mountain Locust (*Caloptenus spretus*), and the second the corresponding ones of our common Red-Legged Locust (*Caloptenus femur-rubrum*). By carefully comparing the illustrations with insects resembling them, the readers will be enabled to know positively whether they have to deal with the one kind or the other. The necessary explanations of the figures in the plates accompany them. (See plates 1 and 2.)

CONCLUSIONS.

All the more sensible and observant people in the infested region, who have watched the methods to exterminate the locusts in 1889, have now reached the conclusion that it is possible to successfully fight and exterminate this intruder, providing active measures are adopted at once, and are, moreover, carried out faithfully. Prompt, intelligent and concerted action is necessary. It is now the common belief among those conversant with the facts that the Rocky-Mountain Locust pest has been brought under control, and the few eggs that may be laid by some of the insects which will escape, need not cause any fear. If everyone owning a farm in the infested region will only properly cultivate the same, will plow it during the fall, and seed it in spring, no fears of losses in 1890 need be entertained. All indications from the far west, or from the breeding grounds of the Rocky-Mountain Locust, indicate no danger from that quarter for a new invasion.

EXPLANATION OF PLATE 1.

Unless otherwise stated, all the figures are enlarged, the increase in size usually indicated.

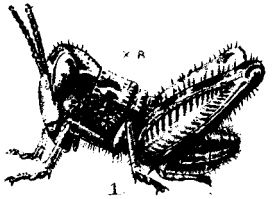
Fig. 1.—*Caloptenus spretus*, newly hatched, or in first larval stage, from side; 1 b, same, while yet pale, from above.
Fig. 2.—Second stage; 2 b, thorax, from above; 2 c, thorax, from side.
Fig. 3.—Third stage; 3 b, thorax, from above; 3 c, thorax, from side.
Fig. 4.—Fourth stage, or first pupal stage; 4 b, thorax, from above; 4 c, thorax, from side.
Fig. 5.—Fifth stage, or true pupa; 5 b, thorax, from above; 5 c, thorax, from side; 5 d, pupal exuviæ, or last skin shed.
Fig. 6.—Sixth stage, or mature insect, the figure showing a typical male from the permanent breeding grounds; 6 a, smaller form, as hatched in the lower and moister country, where the species is not indigenous—natural size.
Fig. 7.—Typical female, with wings expanded—natural size.
Fig. 8.—Antenna of mature insect.
Fig. 9.—Enlarged thorax of mature insect, from above; 9 a, same, from side.
Fig. 10.—Anal characters of male, from above; 10 a, same, from side; 10 b, same from behind.
Fig. 11.—Anal characters of female, from side.

EXPLANATION OF PLATE 2.

Unless otherwise stated, all the figures are enlarged, the increase in size usually indicated.

Fig. 1.—*Caloptenus femur rubrum*, newly hatched, or in first larval stage, from side; 1 b, same, while yet pale; 1 a, antenna of same.
Fig. 2.—Second stage; 2 a, antenna; 2 b, thorax, from above; 2 c, thorax, from side.
Fig. 3.—Third stage; 3 a, antenna; 3 b, thorax, from above; 3 c, thorax, from side.
Fig. 4.—Fourth stage, or first pupal stage; 4 a, antenna; 4 b, thorax, from above; 4 c, thorax, from side.
Fig. 5.—Fifth stage, or true pupa; 5 a, antenna; 5 b, thorax, from above; 5 c, thorax, from side; 5 d, pupal exuviæ, or last skin shed.
Fig. 6.—Sixth stage, or mature insect, the figure showing a typical male—natural size.
Fig. 7.—Typical female, with wings expanded—natural size.
Fig. 8.—Antenna of mature insect.
Fig. 9.—Enlarged thorax of mature insect, from above; 9 a, same, from side.
Fig. 10.—Anal characters of male, from above; 10 a, same, from side; 10 b, same, from behind.
Fig. 11.—Anal characters of female, from side.

PLATE 1.



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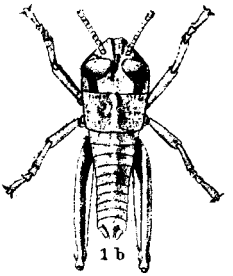
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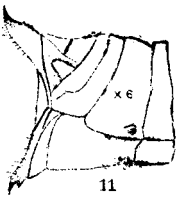

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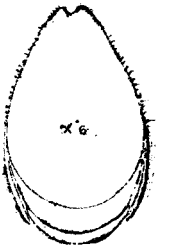

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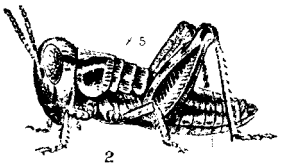
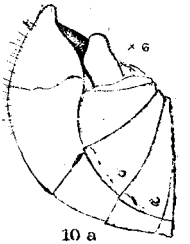


2


2 b


2 c



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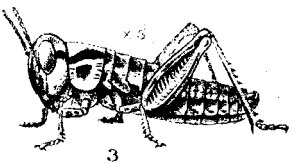

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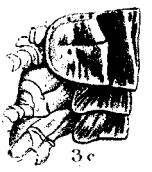
3 b


3 c


4


4 b

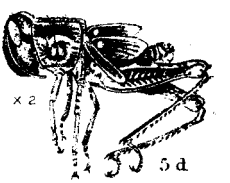

4 c

10

5


5 b


5 c



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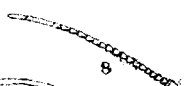
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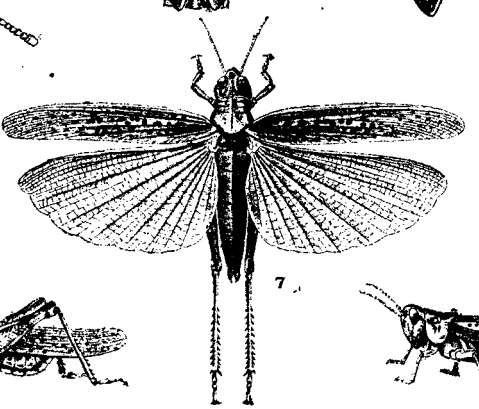
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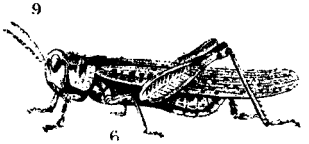
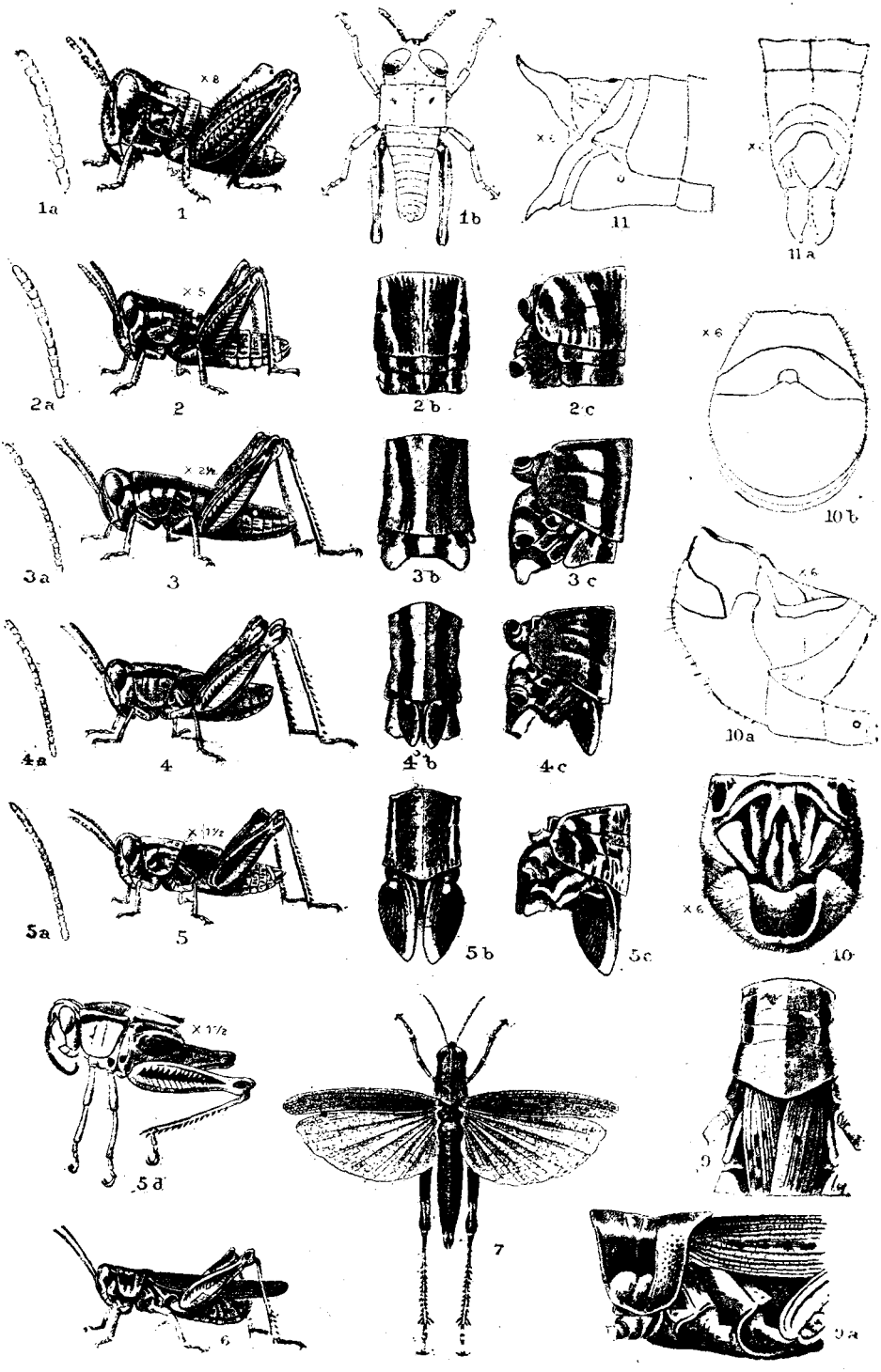
9 a


6


6 a

PLATE 2.


1a
1
1b
11
11a
2a
2
2b
2c
10b
3a
3
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4c
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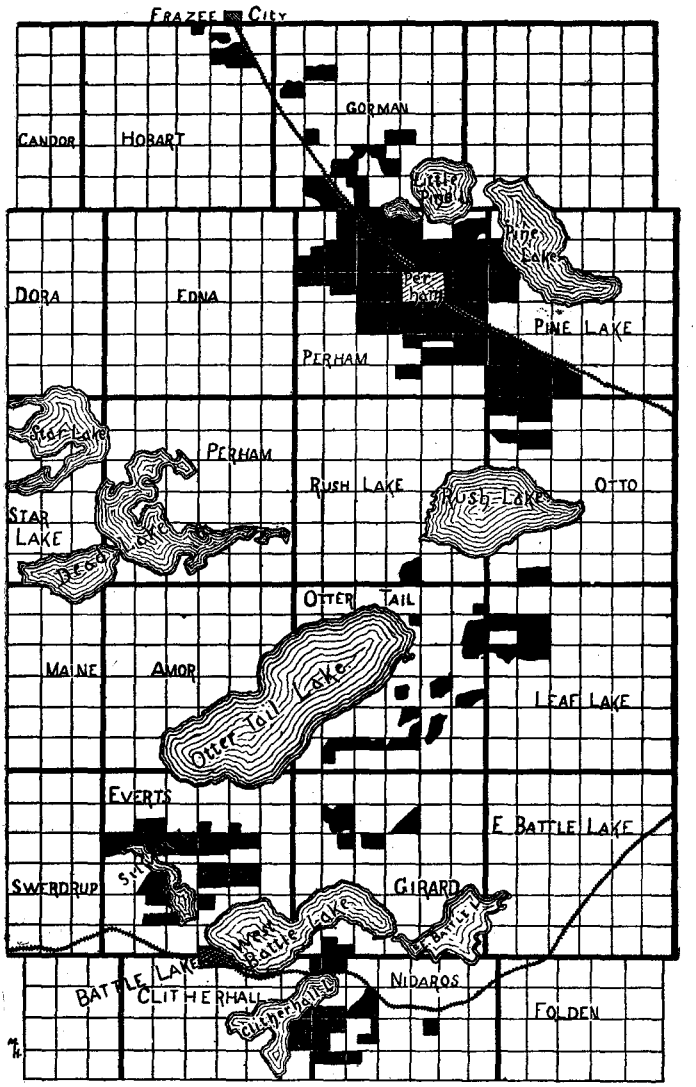
5d
7
9
6
9a



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