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Migratory Locusts in Minnesota in 1891.

By Otto Lugger, Ph. D.

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

NOTE. On the 5th day of last October our station office building was destroyed by fire. The laboratory, a large part of the library, and all Reports and Bulletins from 1 to 12 inclusive, were burned. It will be impossible to supply copies of Bulletins issued earlier than No. 13.

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MIGRATORY LOCUSTS IN MINNESOTA IN 1891.

OTTO LUGGER.

The year 1891 has been remarkable, as far as insects are concerned, for a multitude of very noxious insects. Species, in former years rather uncommon, have appeared in vast numbers, causing more or less alarm on that account. A number of reasons may be given for such a state of affairs; but the present bulletin is not the proper place to discuss them. The chief causes may, however, be stated to be exceptionally mild winters and uniformly favorable growing seasons.

Among the numerous injurious insects of 1891 none are more dangerous than the various species of locusts or grasshoppers. Besides the native species, which in seasons favorable to locusts are always more or less injurious, we have to deal at present with three kinds of migratory locusts, *i. e.*:

Rocky-Mountain Locust (*Melanoplus spretus*, THOMAS).

Lesser Migratory " (*Melanoplus atlantis*, RILEY).

Pellucid Locust (*Camnula pellucida*, SCUDD).

In the report of the entomologist to the Board of Regents, published in the Biennial Report for 1890, page 17, the following statement was made:

"But the danger of fresh invasion remains, and it is in the line of wise legislation to take time by the forelock, and provide the necessary means for suppressing another outbreak. The Rocky Mountain locusts are becoming very numerous in their native breeding places, and have already produced some swarms extending beyond their usual haunts. In fact a large swarm of locusts passed on August 14, 1890, over Crookston, flying in a southeasterly direction. It is true the few mutilated specimens received by the entomologist indicated three native species, but this material was insufficient to furnish proof that the 'hateful grasshopper' was not a member of this swarm. Through the kindness of the St. P., M. & M. R. R., the entomologist was enabled to inquire into this matter, and found that this swarm had continued its flight from Crookston over Foston, and had landed near to and in the upper Rice Lake, in the White

with Indian reservation, where the great majority of the insects composing this swarm perished. Some eggs were deposited near Crookston, and special attention should be paid to the locusts resulting from them; it could not be learned that others had been laid elsewhere. It will be very wise to recollect that the number of locusts in their home have reached the danger mark, and may, if favored by a suitable season, become not simply a menace but a reality."

After the publication of that report more material was received, which proved beyond doubt that the swarm entering the Red River valley was composed mainly of migratory species. But even without such additional proofs it was quite certain that we had to deal with migratory species, as our native ones, not being able to make extended flights, did not form such large swarms. Notwithstanding the evidence and warning of danger, no preventive measures were adopted and the intruders were allowed to settle in the infested region.

Early in June a number of newspapers published complaints that locusts were doing considerable damage in some fields, mainly near Pelican Rapids, Otter Tail county. A visit to that region indicated that a small swarm of locusts had deposited their eggs in that locality, but that timely work would suffice to kill all the young insects, as they were small at that time. The species found at Pelican Rapids was the Lesser Migratory Locust re-enforced by very numerous specimens of the two-striped species. No real Rocky-Mountain Locust could be found. Later reports of damages caused by locusts in various parts of the Red River valley reached His Excellency Gov. W. R. Merriam, who requested me to proceed at once to the infested region, and to do all that could be done at the time to prevent another outbreak of a locust plague. The governor also instructed the county commissioners in the infested region to do all that could be done to stamp out the locusts in their respective counties.

When I reached the Red River valley it was almost too late in the season to perform real effective work, as the great majority of these injurious insects had already acquired wings. Near Crookston, Polk county, the chairman of the county commissioners, Mr. Kirsch, had already commenced operations, and had done some very good work, both by plowing infested fields and by poisoning the grain growing upon ad-

joining ones. In fact, in several cases he had killed the insects to such an extent that but very few escaped. If his example had been followed everywhere the majority of the dangerous kind of locusts would have been killed; but owing to a belief that the species found in such numbers was only a harmless one, few farmers adopted his methods, while many others even ridiculed the idea of having any migratory insects in the county at all. It is rather peculiar what strange false memory will play in some cases. Among others some farmers who had passed through former grasshopper trouble claimed that the Rocky-Mountain Locusts were insects fully two, three, or, even four inches in length, and that moreover were provided with six wings!

As soon as possible a large number of hopper-dozers were constructed, and were distributed by County Commissioner Kirsch to all farmers who wished to use them. Both hopper-dozers and kerosene oil were furnished free by the county, and many farmers set to work to kill as many of the intruders as possible. The insects, being already winged and very active, could no longer be caught during the day; but towards evening when they crawl to the highest points of the plant to escape the chilling effect of the moist soil the machines proved of great value, and immense numbers of locusts were killed. Various modifications of the hopper-dozers (Fig. 1) were used to suit the varying conditions of the fields and of the crops. Other intelligent farmers and merchants living in the counties of Marshall and Kittson obtained models of these machines and commenced in earnest to destroy their enemy.

A close inspection of the invaded region showed that the sandy ridge running north and south through the counties of Polk, Marshall and Kittson was more or less infested in spots. *Without any exception locusts were found only in fields that had been plowed in July and August 1890, or before the invading insects had deposited their eggs.* * In no case were locusts found in the native prairie, nor in any soil that had been plowed late in fall or early in spring. These observations coincide exactly with those made a few years ago in Otter Tail county, and indicate very plainly how to prevent

locusts from causing injury in 1892. This inspection also showed that we have to deal not alone with one kind of migratory locusts, but with two other species equally injurious. Near Crookston the Lesser Migratory species is the most common one, but farther north the Rocky Mountain locust becomes more numerous, and in the extreme north of Kittson county the Pellucid locust is very abundant. The two former species prefer the dry and more sandy soil, the latter the richer and moist land.

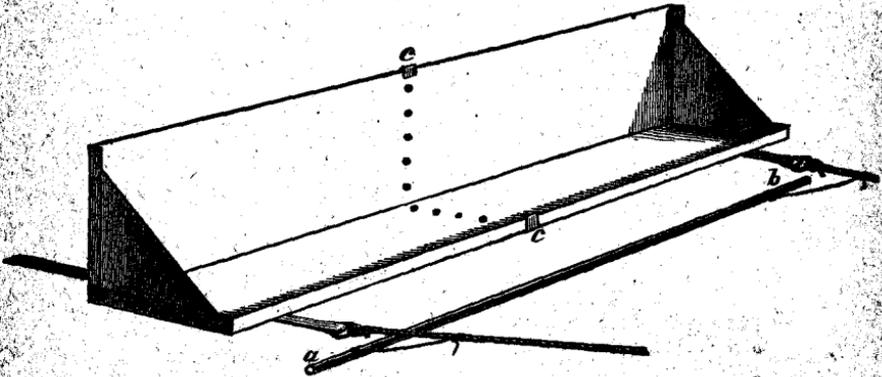


Fig. 1. The Hopper-dozer.—After Riley.

The life-history of the Rocky-Mountain Locust has been given in former bulletins, but as all the remaining copies were destroyed by fire the essential points will be repeated.

ROCKY-MOUNTAIN LOCUST.

(*Melanoplus spretus*, THOMAS).

The permanent breeding grounds* of this locust extend chiefly along the eastern Rocky-Mountain range, from longitude 102° to 140° west of Greenwich, and from latitude 53° to 40° north, comprising most of the levels below an altitude of 6,000 feet and above 3,000 feet. In many portions of this area they breed every year, and lead an essentially migratory existence. This permanent breeding area gradually shades into a sub-permanent region, in which locusts breed more or less frequently, and which is liable to be invaded at any time or rather whenever the insects become very numerous in their true breeding grounds. This region includes a large

*First Annual Report of the U. S. Entomological Commission on the Rocky Mountain Locust.

portion of British America, nearly all of the Dakotas, Western Nebraska, Northwest Kansas and the northern half of Colorado. Although Minnesota may be said to be located in the temporary region, *i. e.* a region only periodically visited, yet parts of the state are unpleasantly near the boundary or danger line, and therefore apt to be overrun by hordes of hungry locusts, and such has been frequently the case, as can be seen in former reports. From 1863 to 1878 there was hardly a year in which locusts did not occur in sufficient numbers to injure the crops somewhere. When not occurring elsewhere they were surely found in the Red River Valley. They did not breed there during all these years, but sufficient new swarms came from the northwest to recruit the invading army and make it formidable. In 1877 they destroyed alone in nineteen counties 337,188 acres of wheat.

In fig. 2 is given an illustration of this voracious species, natural size, and in fig. 3 are shown the early stages of the same species.



Fig. 2. Rocky-Mountain Locust: Natural size. After Riley.



Fig. 3. Rocky-Mountain Locust—*a*, newly hatched larvæ; *b*, full-grown larvæ; *c*, pupa. After Riley.

LESSER MIGRATORY LOCUST.

(*Melanoplus atlanis*, RILEY).

This locust, resembling very closely the Rocky-Mountain species, is a little smaller. Like the former species it has wings much longer than the body, and is thus enabled to fly long distances. It is essentially an eastern species, and is found in larger or smaller numbers from the northern part of Florida to the extreme north of eastern United States. Like the hateful western locusts it is single-brooded in Minnesota, but has the tendency to become double-brooded, a property in our favor, as all the young that may hatch during a warm autumn are doomed to die. The species matures more rapidly than the Rocky-Mountain species, becoming already winged quite early in July. Eggs are deposited soon afterwards, and

oviposition continues till cold weather.

The life history is almost identical with that of the better known western species.

This species is very destructive, and the great losses to all sorts of crops sustained in different regions of New England from locusts are all owing to this insect.

PELLUCID LOCUST.

(*Cannula pellucida*, SCUDD.)—Fig. 4.

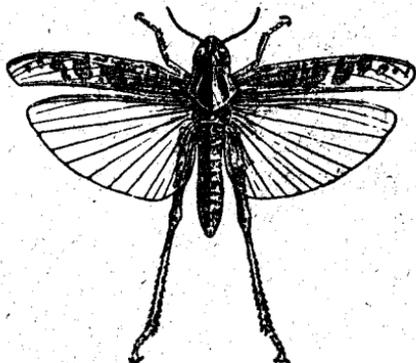


Fig. 4. The Pellucid Locust. Natural size. After Emerson.

This locust belongs to the sub-family to which the North African and Asiatic species belongs, a species so well described in holy scripture. It is much more robust than either the two other migratory species. The Pellucid locust has a rather wide distribution, occurring in California, Utah, Wyoming, Colorado and other western states, and also in the New England states. It occurred in immense swarms in California during the years 1877, 1878 and 1879 leaving devastation in their wake. Again, in company with the other two migratory species now found in Minnesota, it caused great injury in the upper Missouri and Yellowstone valleys. The flight of these Pellucid locusts is quite different from that of the two other kinds, as they do not rise to a very high elevation, nor do they fly so continuously.

The differences between the migratory species and our common Red-legged Locust (Fig. 5) are slight, but easily perceived if once studied. Besides the shorter wings of the Red-legged species, which prevent it from making extensive

figs, the male characters are the chief features that



Fig. 5. Common Red-Legged Locust. Natural size. After Riley.

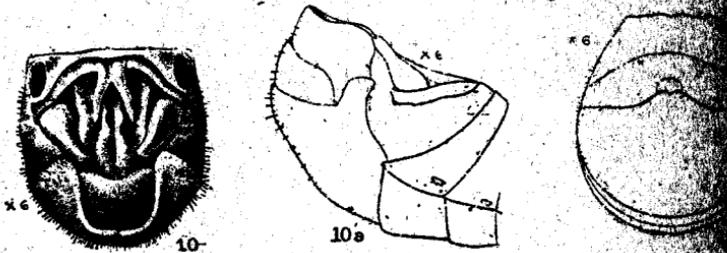


Fig. 6. Red-legged locust, anal characters of male; 10, from above; 10a, from side; 10b, from below. Enlarged six times. After Riley.

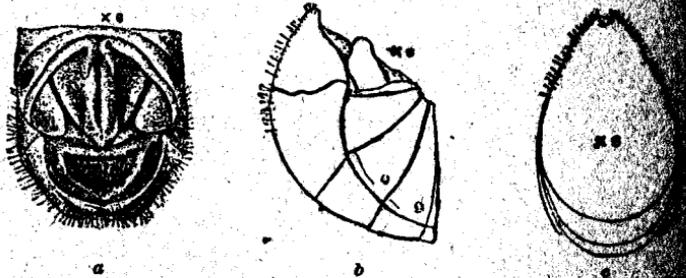


Fig. 7. Rocky-Mountain Locust, anal characters of male; a, from above; b, from side; c, from below. Enlarged six times. After Emerson.

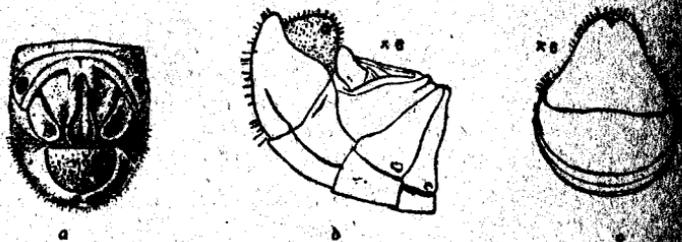


Fig. 8. Lesser Migratory Locust, anal characters of male; a, from above; b, from side; c, from below. Enlarged six times. After Riley.

us to distinguish between the three allied species: Rocky-Mountain Locust, Lesser Migratory Locust and Red-legged Locust. By comparing carefully the illustrations (Figs. 6, 7, and 8) with suspected species of locusts the reader can soon determine for himself which species he has to deal with.

The third species, the Pellucid Locusts (Fig. 4), now injurious in the Red River Valley, is quite different from any of the above three species. Many other locusts occur in large numbers in the infested region and are frequently mistaken for the migratory species. A close inspection of the illustrations below will show that they are quite different, and need not, with a little attention, be mistaken for any of the migratory species.

Fig. 9 gives an illustration of the common native Two-striped Locust, an insect very numerous throughout the infested region, and doing considerable damage.



Fig. 9. Common Native Two-striped Locust. Natural size. After Riley.

Fig. 10 shows the common Differential Locust, an insect also found in the State.

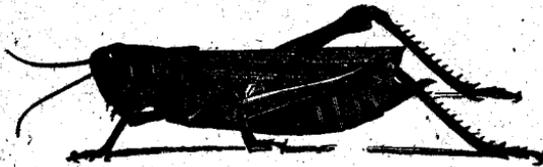


Fig. 10. Common Differential Locust. Natural size. After Riley.

Fig. 11 illustrates the common Coral-wing Locust, a species at once distinguished by coral-red hind wings, and by

a greater size—this insect is frequently mistaken for the migratory species.



Fig 11. Common Coral-winged Locust. Natural size. After Riley.

Remedies. Besides the usual methods of killing locusts, some of which are very valuable if carried out at the proper time, there is but one other excellent remedy left to prevent further injury: plowing the ground after eggs have been laid. This remedy has been applied two years ago on a large scale in Otter Tail county and has proved a complete success. As the conditions in the newly infested regions are similar, there is no doubt that similar results will be obtained if the same remedy is carried out thoroughly. All the locusts now infesting the invaded counties came from fields that were not plowed. In places where the whole of the cultivated soil was plowed, no locusts could be found. Of course at the time of writing this bulletin the state of affairs is different, as the insects have scattered over a much larger area. But if every farmer will plow all his stubble land either this fall after the eggs have been laid, or in early spring, no fears of losses by locusts need be entertained. But to make the reader understand the case more clearly it is necessary to describe in detail how the eggs are laid, and what effect plowing will have. I quote from Bulletin 8, published by the Station during July, 1889.

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 impor-



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

tant 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 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, until 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.

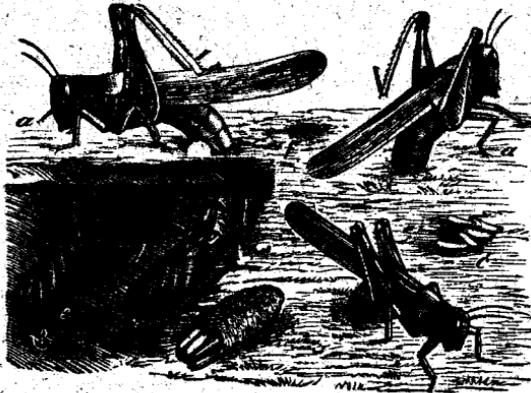


Fig. 2.—Rocky-Mountain Locust—*a, a*, female in different positions, ovipositing; *b*, egg-pod extracted from ground, with the end broken open; *c*, a few eggs lying loose on the ground; *d, e*, show the earth partially removed, to illustrate an egg mass already in place, and one being placed; *f*, shows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

“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 escape

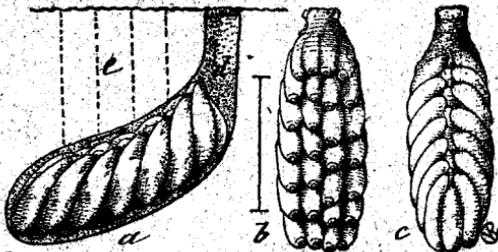


Fig. 3.—Egg-mass of Rocky-Mountain Locust—*a*, from the side, within burrow; *b*, from beneath; *c*, from above, enlarged. (After Riley.)

from these last, were there no provision against such a pos-

sibility. 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 issue 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 embryo 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 embryo 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 tibiae, the shell is eventually broken, and the young locust pushes its way through the neck of the burrow towards the light.

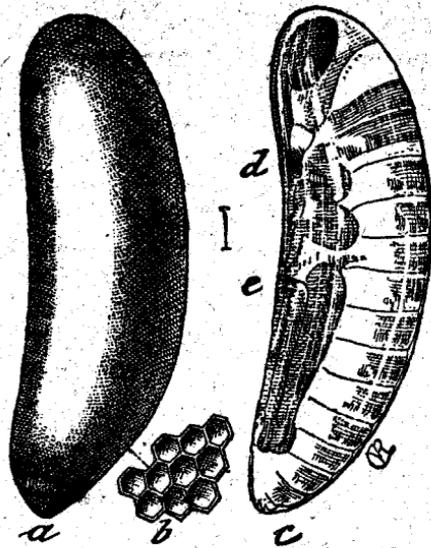


Fig. 4.—Egg of Rocky-Mountain Locust—*a*, showing sculpture of outer-shell; *b*, the same very highly magnified; *c*, the embryo, just before hatching. (After Riley.)

“Nearly always all the eggs in a pod hatch at the same time and the young escape through the small hole left for the 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 envelopes 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 seen, it is shed within a few minutes of the time when the

When it reaches the free air, it is seldom shed, if, from one or other, there is a failure to escape from the soil, even when the young locust may be struggling for days to effect an escape.

While yet enveloped in this pellicle, the animal possesses a forcing and pushing power, and if the soil be not too compact, will frequently force a direct passage through the soil to the surface, as indicated at the dotted lines (Fig. 3). But if the soil is at all compressed it can make little or no way, except through the appropriate channel (Fig. 4).

While crowding its way out, the antennæ and four legs are held in much the same position as within the soil, the hind legs being generally stretched. But the membrane is forced in every conceivable way and where several are endeavoring to work through any particular passage, the result of squeezing and crowding they will endure is somewhat remarkable. Yet if by chance the protecting pellicle is broken off before issuing from the ground, the animal loses its 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 legs downwards towards the bottom whenever the tubes were turned downwards; while in tin boxes, where the eggs were hatched at different depths in the ground, the young never issued, even when they were unable to ascend on account of the compactness of the soil above."

In the above minute account of the manner in which eggs are hatched and how the young insects are enabled to reach the surface, I have only indicated 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 the method of 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 a normal amount of rain, we also effectually prevent their hatching and 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."

To repeat again: If we desire to get rid of the migratory species of locusts now infesting several counties in the State it is absolutely necessary to plow every inch of the cultivated ground throughout the invaded region. Of course prairies are excepted, the soil in them being filled with a dense mass of roots, thus being unsuitable for the purpose of egg-laying. Simply cultivating in spring, as advised by some, is perfectly useless, and proved a total failure where tried. Summer-fallow invites the locusts to deposit their eggs in soil thus prepared, and all land thus treated must be plowed again, either later in autumn, or early in spring.

Natural remedies. There are at this time many natural agencies in our favor and working for us, and no doubt immense numbers of locusts will be killed by them. Nearly, if not quite all the parasites known to infest locusts are found in large numbers throughout the invaded region. In some places the Red Mite was found in immense numbers infesting not alone the bulky Two-striped Locust, but also those migratory species which love drier soil. In some fields, in which the locusts had hatched, nearly every individual had from five to twenty of these mites fastened to its under wings, and the locusts were doomed. Evidently they knew this as well, as they did not move about in such a lively manner, but seemed out of sorts. But these were exceptional cases, as all the adjoining fields of wheat were overrun with healthy specimens—too healthy to suit the farmer. The explanation lies in the fact that the healthy locusts had escaped all danger from the Red Mites by migrating to the land of plenty, the wheat

fields. Numerous other parasites occurred almost everywhere, but chief among them was one of the old fashioned Potato-beetle, or Blister-beetle. This insect (*Epicauta pennsylvanica*) was so numerous as to seriously injure the potato crop. And yet, though very injurious to potatoes, this beetle ought to be protected for once, as in its earlier stage it feeds exclusively upon the eggs of the locust. Many predaceous insects are also in full operation to reduce to some slight extent the numbers of the intruders. It was a cruel, yet withal a pleasant sight, to see the large numbers of Ground-Beetles (*Calosoma calidum*) giving battle to the locusts. Even large specimens were attacked, and notwithstanding a most desperate struggle the locust was soon consumed. Another beetle (*Pasimachus spec.*), much more shy in all its actions, being a nocturnal insect, was found in large numbers engaged in devouring the enemy. Even spiders assist in this good work, and a number of the common Wolf spiders (*Phydippus punctatus*) were seen to attack and kill locusts.

Needed legislation. In conclusion I quote from Bulletin 8 of this Station: "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 of 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."

Report to his Excellency Governor W. R. Merriam in regard to the migratory locusts infesting portions of Minnesota :

On August 14, 1890, a large swarm of locusts or grasshoppers entered the state of Minnesota. They were observed in a number of places, but chiefly at Crookston, Hallock and other points in the Red River Valley. This swarm came from the northwest, and flew in a southeasterly direction. Through the kindness of the Great Northern Railroad I was enabled last summer to make close inquiry in the regions where this swarm had been observed, and I could follow one that had passed Crookston in an easterly direction to Foston into the White Earth Indian Reservation where immense numbers of the locusts composing it had perished in the upper Rice Lake. Close inspection also revealed the fact that eggs had been deposited in some places. At the time in which the above investigation was made it was impossible to obtain many specimens of the insects composing this swarm, but the mutilated material obtained indicated besides the common native species, at least two species of locusts not usually found with us, one of which was the Lesser Migratory Locust (*Melanoplus atlantis*, Riley), and the second a locust evidently belonging to a different genus, but not identified at the time.

As our native locusts do not form swarms like the one invading Minnesota on August 14th, 1890, it was quite certain that we had to deal with species more formidable and dangerous, and I deemed it my duty to call attention to this invasion stating that it was in the line of wise legislation to take time by the forelock, and provide the necessary means for suppressing another outbreak. This was done in the last Biennial Report of the Agricultural Experiment Station, page 17. For some reason, however, no action was taken.

When a swarm of locusts passes a region, the females, heavy with maturing eggs, are very apt to lag behind and drop to the ground whenever the soil is of such a character as to invite them to deposit their eggs. Suitable for such a purpose is all soil that is well drained, and which contains very few roots of plants.

Early in June of the present year a number of letters were received from different parts of the state about exceptionally large numbers of locusts. This was to be expected, even without the addition of the migratory species, as the last few seasons had been greatly in favor of all kinds of locusts and other insects that thrive best in dry and hot

summers following a mild winter. The first alarm, in the form of articles in some of our daily papers, came from Pelican Rapids in Otter Tail county. My investigation of this case showed that a small area near that place had been infested, but chiefly by various native species, and the Lesser Migratory Locust. Paying proper attention to this local trouble removed cause for alarm.

The attention of your Excellency was next drawn to the more alarming reports coming from the Red River Valley, and you ordered me to proceed at once to the infested region, and for the last forty days I have been engaged in traveling through the different counties invaded and in instructing farmers in the proper means to combat their enemy.

In Minnesota five counties are infested with migratory species of locusts. Three distinct species, besides the native, are now causing well founded alarm. The Lesser Migratory Locusts (*Melanoplus atlanis*, Riley) are the most abundant species. The true Rocky Mountain Locust (*Melanoplus spretus*, Thomas) is also very common, and the Pellucid Locust (*Camnula pellucida*, Scudd.) occurs also in alarming numbers in the more northern part of the invaded region. The Two-striped Locust (*Melanoplus bivittatus*, Scudd.), though a native species, is exceedingly numerous in many places and causes considerable damage.

The Lesser Migratory Locust occurs in very large numbers in parts of the counties of Polk, Marshall, Kittson, Otter Tail, and Hubbard, and extends eastwards as far as the cities of Duluth and Tower, St. Louis Co., and is doubtless found in more isolated swarms in the whole northern part of the state. The Pellucid Locust occurs only in the lower or moister parts of Kittson county, and is also found in considerable numbers at Pembina, N. Dak.

We have to deal in this instance with three of the worst species of locusts found in the United States. The region invaded is quite well defined and the insects occur thus far only in certain spots, but of course this state of affairs will be somewhat changed during the month of August. The central parts of Polk, Marshall and Kittson counties, from south to north are more or less affected, or in other words the sandy ridge running from south to north in above counties is invaded by the Lesser and by the Rocky-Mountain Locust. Evidently this sandy ridge attracted the females to deposit their eggs, or the eggs laid elsewhere in the black and more

moist soil did not hatch. The former theory is very likely the true one, as the instincts of the female prompt her to deposit her eggs wherever there is good drainage, an important factor to the well-being of the eggs of those insects. But not the whole of this more or less sandy region is thus infested, as the locusts occur only in well defined small areas. A close inspection of several hundreds of fields revealed the undisputable fact that all eggs laid by the invading swarm were laid in stubble fields and in summer-fallow. In no case were the locusts found in the prairie, or in fields not surrounded by or adjacent to stubble fields. All the dangerous locusts hatched there, and thence invaded the neighboring fields of grain. In a large number of cases the young locusts marched in regular order to the fields of barley, wheat and oats, and swept away every trace of vegetation for several rods, in some cases many acres. As they grew older they scattered around more, and the exceedingly rank growth of the grain shows at the present time but slight damage. In badly infested fields, however, nearly all the foliage has been eaten, and the heads alone remain. Even these are now devoured in many instances, but only in the more sandy regions. There is still considerable danger to the crops in some parts of the infested regions. As the foliage of the various kinds of grain becomes older and riper it becomes also unfit for food, and the locusts will be forced to attack the growing part of the plants, the heads. In some fields this is already the case, and the locusts eat out the growing kernel, or even bite off the whole ear.

Both the Lesser and the Rocky Mountain Locust infest mainly the more sandy and drier region of the invaded county. The Pellucid Locust seems to prefer entirely different localities and is at the present time only found in the lower and moister regions chiefly in the northern part of Kittson county, and in the corresponding parts of N. Dak. There it is quite injurious and may prove even a greater enemy than either of the other migratory species.

All these locusts, although very numerous in some regions, are as yet not numerous enough to cause very serious loss to the general crop. Many farmers will lose a large part of their crops, some few may lose even everything.

All these species of locusts, being fresh arrivals from the northwest, are in a remarkably healthy condition, and consequently much more dangerous than if they had been here some time longer. The two species loving dry and warm

soil show this to a remarkable degree. If stubble fields in which the eggs were laid, are investigated at this time, it will be found that fully one half of the locusts are infested with their deadly enemy, the Red Mite, and this in most instances to such a degree that they will be disabled and unable to deposit eggs for another generation. But if we investigate the adjoining fields with their promising crops of grain we soon discover a very different state of affairs. Here almost every locust is free from parasites, and enjoying life in grasshopper fashion to the fullest extent, and the intruders will be able to deposit immense numbers of eggs. Evidently the locusts infested with parasites take a gloomy view of life and have lost their usual energy to such an extent as not even to migrate to the adjoining land of plenty. The common Two-striped Locust of the Red River Valley although quite an injurious insect if numerous, is now badly infested with numerous kinds of parasites and is consequently to be considered as a friend, since the parasites infesting it will next spring take possession of the invading species. All the important species of parasites occur in fairly large numbers throughout the infested region. One species, the common Black Blister-beetle, is at this time so numerous as to seriously damage the potato crop; it is even much more numerous and injurious than the Colorado Potato beetle.

Considering the locust invasion in all its bearings the true state of affairs may be summed up in a few sentences. There are not enough locusts to seriously injure the crop of 1891, though some farmers will loose considerable. Many parasites are at hand to assist us in 1892; the great bulk of the invading species are still remarkably healthy, and will lay enough eggs to produce immense swarms in 1892 if not prevented by artificial or natural means. They are still local and can be exterminated by energetic and prompt means.

Your Excellency, knowing the great danger of another locust trouble, perhaps similar to that experienced from 1872 to 1876, has taken the only possible way to prevent it by instructing the county commissioners of the infested regions to take the proper steps for fighting these insects. Some of the commissioners thus called upon have responded cheerfully and have acted at once, but others do not seem to consider the locusts as dangerous enough to cause serious losses. Such a view is very short sighted. Even if these injurious insects do not seriously endanger the crop of 1891 they will assuredly do so in 1892 if not stamped out in time. "An

ounce of prevention is worth a pound of cure," is an old saying, but a very true one, and ought to be made the leading impulse in our work against these intruders. In Polk county a large number of hopper-doers have been in operation under the intelligent and energetic leadership of the chairman of the county commissioners, and have done good execution. As all the locusts, or nearly all, were already winged when the machines were put in operation very little could be done with them during the warmer parts of the day, but late in the evening, during the night and early in the morning, when the insects are sluggish and crawl up to the highest parts of the plants, immense numbers were killed and many fields could thus be saved. At the present time the grain is too far advanced to use such machines, except in extreme cases. The only remedy and the only one that will effectually do the work is plowing all the fields known to contain the eggs of locusts. If a good crop is secured next month a large portion of the cultivated land will be plowed, thus killing off immense numbers of locusts in 1892. But all the other cultivated land should also be plowed after the eggs have been laid. The locusts have commenced to mate and will soon deposit their eggs, and continue this work until some time in September. This time of egg-laying depends of course upon climatic conditions and may be greatly shortened or lengthened. At all events, however, no land should be plowed before all the eggs have been deposited. If already plowed or plowed before the eggs have been laid a second plowing later in autumn or as early as possible in spring, will be absolutely necessary. The locusts prefer ground free from roots and well drained. Such ground we furnish them now by summer-fallow, and later by early plowing. All fields treated in this manner are very suspicious and ought to be plowed again.

I have recommended that instead of summer-fallowing, to plow now only to a depth of two inches and later to the usual depth. Concerted action is absolutely necessary and the ignorant or slovenly farmer should not be permitted to endanger the future crops of his neighbors and perhaps that of a large part of the state. The County Commissioners can help greatly in this good work, and should if necessary force all farmers to do their duty to themselves and to their fellow farmers. In this connection permit me again to call your attention to the fact that the state of Minnesota needs some laws to protect the good farmers against injurious in-

sects raised by the poor ones. Locusts ought to be classified with certain contagious diseases, like the small pox for instance, and similar laws ought to be framed to suppress these insects as such diseases.

Generally speaking the climatic conditions prevailing this summer have been greatly in favor of the farmer and have been and are against such of the migratory species of locusts which love and thrive best in a hot and dry season. This will account for the fact that but few locusts have been seen flying long distances. The great abundance of moisture has made them sluggish and prevented their flight. Long continued moisture is very injurious to insects of that order, and may greatly assist us by diminishing their number, by enfeebling many, and by preventing the depositing of eggs except in certain regions well drained. But it would be very unwise to trust entirely to such favorable climatic conditions or to any other natural means to help us. We must help ourselves and only conscientious work will attain that end. If favorable climatic conditions should assist us it will still be necessary to inspect carefully all infested or even all suspected fields, and have them plowed regardless of cost.

As usual in such cases the railroads in the infested regions have shown their interest in the war against the locusts, and thanks are due to both the Great Northern and Northern Pacific Railroad for furnishing free transportation over their lines.

Very Respectfully Yours,
OTTO LUGGER.

St. Anthony Park, Aug. 1st, 1891.