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Grasshoppers and Their Control

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IN some of the western states, grasshoppers have become the determining factor as to whether a farmer will stay on his land or move out. As long as the drouth period continues, these dry-weather insects have the advantage and farmers will have to continue to control them from year to year if they are to prevent final calamitous outbreaks.

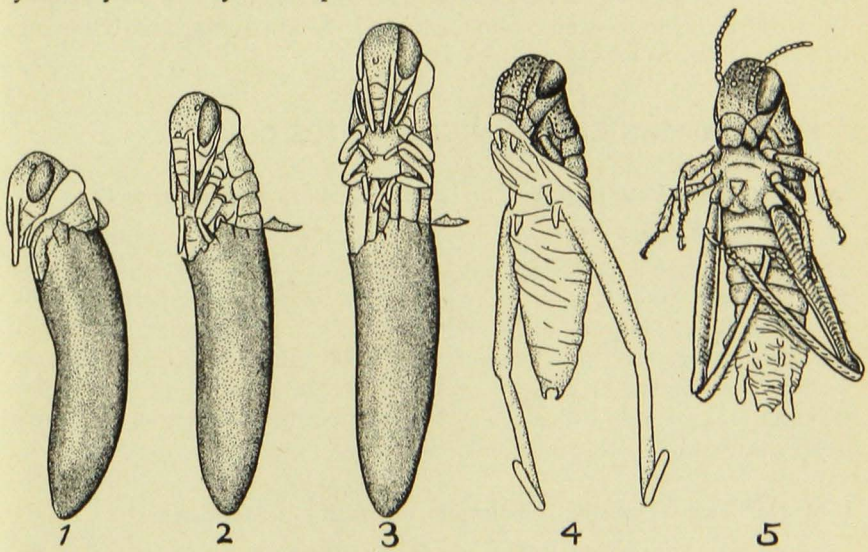

Fig. 1. Grasshopper Hatching from Egg

We are, therefore, not dealing with a new or extraordinary pest but rather with a common and well-known insect. The grasshoppers we are now contending with are native to the state and ordinarily are not present in large numbers. However, if favorable dry weather conditions occur, particularly long, ideal egg-laying periods during the fall and ideal weather for development of young 'hoppers during June, they often increase to tremendous numbers.

An enormous crop of grasshopper eggs, a potential threat to many millions of dollars' worth of crops, can be checked if timely and effective control measures are instituted by all of the farmers in the infested or threatened areas.

AGRICULTURAL EXTENSION SERVICE
University of Minnesota U. S. Department of Agriculture

A county agent in Minnesota made the statement that preparation and organization for control, particularly during lengthy drouth periods is without question the cheapest form of insurance obtainable, particularly when the bait is supplied free—in most cases delivered freight paid into the counties. Knowing that organization in itself costs very little, isn't this statement obviously true?

Organization is 90 per cent of the battle in fighting grasshopper outbreaks. In many places, during the years 1931 to 1940, where the number of grasshoppers was enormous and conditions seemed hopeless, well-organized and well-supervised campaigns started early in the season gave nearly 100 per cent protection to the crops. Campaigns completed before the grasshoppers obtain their wings always assure protection to the crops. To wait and see what is going to happen, to operate as individuals, to wait until destruction starts and the grasshoppers are moving from one farm to another results in disaster.

ORGANIZATION NECESSARY FOR CONTROL

Unit No. One—County Agent or Leader (County Organization)

The county agricultural agent or some other person qualified to act as a county leader should be put in charge of the county control campaign by the county commissioners, with their full support and cooperation. The duty of the county agent or county leader will be to establish an effective organization, thoroughly instructed. It will be up to the county agent or leader to arrange for the proper and timely distribution of poison bran bait on public premises such as highways, ditch banks, railroad grades, and public lands.

Unit No. Two—Township Chairman (Township Organization)

Each township in the infested area should have an organization with a chairman. The chairman does not have to be the chairman of the township board, although in most cases that is best. He should be placed in charge of the township control organization by the county agent or leader and should have the support and cooperation of the township board.

Unit No. Three—Assistant Township Chairman (Township Sections)

If the infestation is general, the townships may be divided into four equal parts. The farmers in each will make up the bait-scattering crews. Each of these bait-scattering crews should have a leader or foreman, appointed jointly by the township chairman and the county leader. In other words, the township will have four bait-scattering crews, each with a leader or foreman. It will be up to the members of the bait-scattering crews to spread poison bran bait over all of the infested land. A farmer will not necessarily spread the bait on his own farm. The crew will work cooperatively over all of the infested area.

Summary of Organization

The county agent or leader is responsible to the supervisor. In case of a statewide campaign, the organization described is the ideal set-up. Its areas and units will vary in size and number of individuals, depending upon the population of the township and extent of infestation.

DOMINANT SPECIES IN AREA MAY CHANGE

In the 1932 outbreak, the two-striped grasshopper was the dominant species. In 1934 the clear-winged grasshopper caused most of the damage, and in 1937 the red-legged grasshopper was the most abundant. This change in dominant species is probably closely correlated with the shift of main food plants with weather conditions. As a drouth covering a period of years becomes more severe, so naturally does the plant fauna of the drouth area change, thus directly affecting the insect species in that area. It is well known that drouth generally coincides with grasshopper outbreaks and at times may be so severe that the grasshoppers die of starvation or fail to reproduce unless they migrate to areas where food is more abundant.

PRINCIPAL KINDS OF GRASSHOPPERS IN MINNESOTA

Although there are many kinds of grasshoppers in Minnesota, the following six species cause most of the damage:

Common Name	Scientific Name
The two-striped	*Melanoplus bivittatus* Say
The red-legged	*Melanoplus femur-rubrum* DeGeer
The migratory	*Melanoplus mexicanus* Saussure
The clear-winged	*Camnula pellucida* Scudder
The differential	*Melanoplus differentialis* Thomas
The Carolina	*Dissosteira carolina* Linné

THE TWO-STRIPED GRASSHOPPER, although generally distributed over Minnesota, is most commonly found in destructive numbers in the Red River Valley and west central Minnesota. It is large, measuring up to 1½ inches in length. The yellowish-brown body is marked with a yellow stripe on each side of the back, extending from the head to the end of the wings. The eggs are generally concentrated along fence rows, ditch-banks, borders of fields, and roadsides.

THE RED-LEGGED GRASSHOPPER is smaller than the two-striped grasshopper and is reddish-brown. It is seen most commonly in alfalfa fields and pastures. The hind legs are usually a deep red in color. The eggs of the red-legged grasshopper may be scattered over entire pasture and alfalfa fields.

THE MIGRATORY GRASSHOPPER is approximately the same size and closely resembles the red-legged grasshopper. It does not, however, have the deep red color in the hind legs. It is now thought by many entomologists that the Rocky Mountain locust, so well remembered by some

people who lived during its outbreak in 1873 to 1878 in western Minnesota, is the same as the migratory grasshopper. The species seems to have more of a tendency than other common species to make mass flights from one area to another. It is somewhat scattered throughout the state. The most serious infestations of this species have been found in the Red River Valley, however. It has somewhat different egg-laying habits than our other common species in that it may deposit eggs over large areas of grain stubble. It does not seem to prefer the more solid or soddy places.

THE CLEAR-WINGED GRASSHOPPER is small, about the size of the migratory grasshopper. Its hind wings are clear and the front wings are distinctly blotched with brown. As a rule, the clear-winged grasshopper deposits eggs in sod land such as roadsides, pastures, and meadows.

THE DIFFERENTIAL GRASSHOPPER is a large yellow grasshopper which is easily recognized by the conspicuous black chevrons on each hind leg. This species is most commonly found in southwestern Minnesota, although its range extends as far north as Barnesville and as far east as Faribault. It deposits its eggs in the borders of the fields, along the edges of cornfields, and in other areas similar to those in which two-striped grasshoppers deposit eggs.

THE CAROLINA GRASSHOPPER OR ROADSIDE GRASSHOPPER will reach a length up to two inches. It may vary in color from a bright yellow to a dark brown, and it is usually mottled with specks of gray and red. The hind wings are black with yellow margins. This insect is found over the whole state. Lately, however, it has in a few cases become extremely abundant in small areas in the Red River Valley. It is not generally so destructive as the other species mentioned. Its eggs are deposited in sandy areas mainly along roadsides and field borders.

LIFE HISTORY OF THE IMPORTANT KINDS

The life histories of the important species mentioned are similar. There is only one generation of grasshoppers a year, and they overwinter in the egg stage. Most of the eggs hatch some time in June, but some may hatch early in May. The young 'hoppers become active and start feeding immediately after hatching. They are small wingless insects and gradually increase in size, molting five or six times before wings are formed. It takes from 40 to 60 days from hatching to reach maturity. Mating and egg laying take place the latter part of July, all of September and October, and until the first good frost. The adults will continue to destroy crops until they are killed by cold weather.

The females may deposit from 30 to 300 eggs in little pod-like masses, each pod containing anywhere from 20 to 100 eggs. If favorable egg-laying conditions extend into the fall, a good many eggs may be laid. In serious outbreaks, as many as 100 egg pods to the square foot of sod have been found.

Number of Generations a Year

As far as we know, these common grasshoppers have only one generation a year in Minnesota. In some states south of Minnesota, however, the lesser migratory grasshoppers were observed to pass through one complete and a partial second generation in 1936 and 1937.

Habits

How Deep Are the Eggs Laid and What Do They Look Like?

Most of the grasshopper eggs are laid in the top two inches of soil. A waterproof secretion or cement-like substance is deposited around the eggs when laid, forming a sort of protective capsule to which particles of dirt cling. When these cylindrical pods are taken from the soil unbroken, they appear as small lumps of dirt, about an inch long and 3/16 of an inch in diameter. This is the approximate size of the pods produced by the most common grasshoppers, the two-striped form. The average pod contains approximately 45 brownish or yellowish eggs, oval in shape, slightly curved, about 3/16 of an inch in length and about 1/16 of an inch in diameter. These eggs are systematically packed and cemented together in the protective pod.

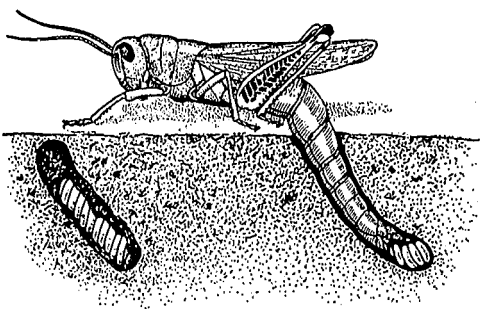

FIG. 2. GRASSHOPPER LAYING EGGS

Where Are the Eggs Laid?

With the exception of the migratory grasshopper, the common grasshoppers of importance in this state prefer to lay their eggs in neglected or uncultivated grassy areas. Sod of some kind is preferable: for example, pastures, borders of fields, along fences, and in other places such as alfalfa fields, hay meadows, weedy areas, waste land, roadsides, ditchbanks, and railroad grades. As a rule, eggs are laid in fairly compact soil, although unusually large numbers of eggs are sometimes deposited in some of the looser soils around the edges of small grain and flax stubble and corn fields. Most of the egg-laying areas are on strips of land 50 to 100 feet wide, bordering or near preferred foods such as flax, corn, alfalfa, small grains, and legumes. A roadside can hatch out enough grasshoppers to destroy the crops on the adjoining fields. Roadsides and ditchbanks may justly be termed "grasshopper incubators." In many cases eggs are laid over large areas of pasture sod, often over entire pastures. It is almost certain that eggs are laid on the edges and strips of land surrounding fields where grasshoppers are present.

Weather conditions at the time of egg laying may have a very pronounced effect on the exact location of the egg beds. For example, in the fall of 1937, on an alfalfa field north of St. Paul it was found that the red-legged grasshopper had deposited its eggs on only one small area of the field where the ground was covered by flat vine-like weeds. Possibly the presence of the ground-clinging weeds made the soil cooler and more inviting to the egg-depositing females. Egg pods ran from two to ten per square foot in the weedy area, while only an occasional pod could be found on the rest of the field.

OVERWINTERING 'HOPPERS

During the late winter months and early spring months we often have reports that grasshoppers are hatching. We always find upon examination that these are species of grasshoppers which, instead of passing the winter in the egg stage, overwinter as young 'hoppers and adults. Some hatch in the late fall and are sometimes found in large numbers near haystacks, in pastures, or near timbered areas. They feed generally upon vegetable mold, decomposing organic matter, algae, lichens, and mosses, and usually are not injurious to the farmers' crops. Some of the most common overwintering grasshoppers found in Minnesota are the slant-faced grasshopper and the "Harbinger of Spring." These species cause excitement among farmers when found moving about during the warm days of the winter months. The destructive grasshoppers in Minnesota usually start hatching during the first half of May.

PREDATORS, PARASITES, AND DISEASES

A number of *parasitic flies* deposit maggots upon the grasshoppers. The most important of this group is known as the "flesh fly." The maggot destroys the internal portions of the grasshopper's body, causing its death. Robber flies destroy numbers of young grasshoppers by grasping them and sucking out the liquid contents of the body. A number of wasps are known to kill or stupify grasshoppers by stinging them. Then they carry them into their underground nests where they lay eggs on the bodies. When the eggs hatch out, the young feed on the grasshoppers.

In the grub stage, the *blister beetle* feeds on the eggs of grasshoppers in the ground. The adult blister beetle is injurious to Caragana, beans, alfalfa, and other cultivated plants.

Birds and many animals, including *mice,* prey on grasshoppers and also destroy some eggs. These birds and animals, however, cannot be expected to prevent outbreaks or to control the grasshoppers under outbreak conditions. Under ordinary conditions, all these birds and animals and other factors of nature are of value and will eventually reduce to normal the large populations of grasshoppers and many other insects. Until all such forces of nature are able to balance the species in the general scheme of things, man must be ready to control these pests in order to protect his crops.

We know that at times in small areas grasshoppers are reduced considerably by *fungous and bacterial diseases.* In general, these diseases require periods of wet weather and proper temperatures. These organisms are always present in grasshopper areas and unless we have the conditions favorable for their development, it will do no good to spread them artificially among these insects. These diseases will not develop and spread under hot, dry conditions. An attempt to spread them by artificial means usually results in a waste of money and time—possibly losses of crop, while waiting for results.

In every grasshopper outbreak, we have many reports that small *red mites* are destroying the grasshoppers. These mites may weaken and kill a very few grasshoppers, but in outbreaks they are not of great importance.

Certain ground beetles and other insects, including the red mites, will feed on grasshopper eggs, but they are not to be depended upon as great factors in reducing grasshopper populations in outbreaks.

FIG 3. A TWO-STRIPED GRASSHOPPER KILLED BY A FUNGUS

CRITICAL FACTORS TO REDUCE LARGE OUTBREAKS—WEATHER

May and June, when the grasshoppers are hatching and going through the early nymphal stages, are the critical months as far as the effects of weather are concerned. It is during this period that rainfall, cold weather, or a combination of both, will reduce large grasshopper populations. Long dry spells in the fall of the year are favorable for heavy and extended egg laying. Extremely hot and dry weather has been known to kill eggs in the soil. Eggs are seldom if ever affected to any great extent by winter temperatures, even when the ground is barren of snow.

CONTROL MEASURES

The principal method of controlling grasshopper outbreaks in Minnesota is the timely and efficient application of poison mash.

It is generally agreed by entomologists, after several years of practical control work involving the use of thousands of tons of bait and after general experimental work, that the use of poison bait is the best known method of grasshopper control. Poison bait made up of pure wheat bran and poison is known to be the most effective, but well prepared bait made up of bran and sawdust is almost as effective, is considerably cheaper, and is much easier to mix and spread than pure bran and poison bait. A number of fibrous materials and other milling products have

been used with some success. In grasshopper outbreaks, however, many of these products cannot be obtained quickly in large quantities.

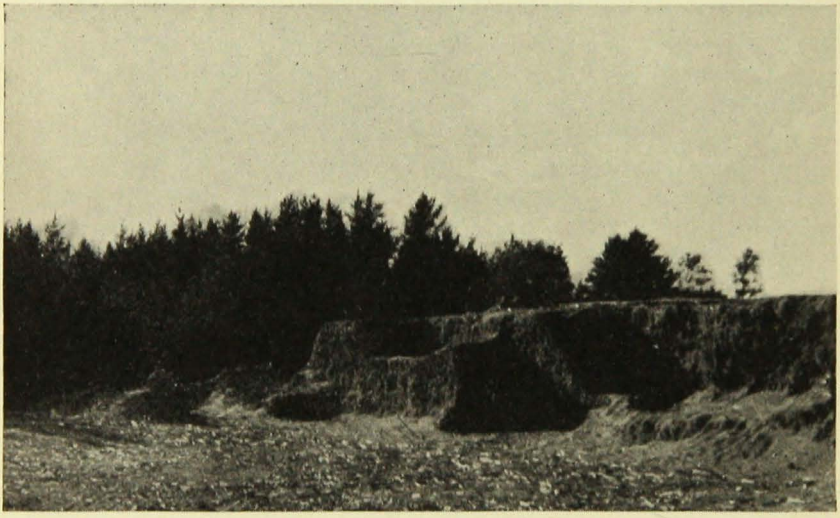

FIG. 4. REMAINS OF A LARGE SAWDUST PILE USED FOR 'HOPPER BAIT IN A MINNESOTA OUTBREAK

WHITE OR CRUDE ARSENIC AND PARIS GREEN are satisfactory poisons to use in grasshopper bait. Paris Green is considerably more expensive than the crude or white arsenic, but it is sometimes economical to use when only small quantities are needed.

SODIUM ARSENITE is the cheapest and apparently the most effective of the poisons. It is a liquid poison which is easy to mix with water and is usually the most convenient to handle at general mixing stations. On farms, it is much harder to handle than Paris Green or crude or white arsenic. When mixing is done on the farms, white or crude arsenic or Paris Green should be used.

SODIUM FLUOSILICATE, at the rate of 3 pounds to 100 pounds of bran or equal bulk of sawdust, has given excellent kills in experimental work. It is less toxic to animals and kills the grasshoppers considerably quicker than arsenic, and its use would lower the hazard of accidental livestock poisoning. It costs more than either liquid sodium arsenite or crude arsenic and is not available in as large quantities as the arsenic.

Materials Not To Be Used

ARSENATE OF LEAD, CALCIUM ARSENATE, AND SODIUM ARSENATE are of little value and should never be used in grasshopper bait.

EPSOM SALTS (magnesium sulphate), the growing of CASTOR BEAN plants, or the use of FLY SALTS (or salts containing sulphur) are not recommended for grasshopper control. During 1936 and 1937 certain

pseudo scientists recommended Epsom salts and fly salts to replace the poison in grasshopper bait. Experiments indicated that these materials did not control grasshoppers. The growing of castor beans, which are supposed to repel the grasshoppers and to kill them when the insects feed upon them, should not be depended on. Information to date indicates that the planting of castor beans will not control grasshoppers, nor will it protect the crops against grasshoppers. The planting of castor beans may be dangerous to other animals. When scientific data are available on the use of castor beans, full publicity concerning any possible merits will be given. In the meantime, use the well-known and proven methods of control—spread poison bran bait, relying on crude or white arsenic, Paris Green, or sodium arsenite as the poisoning agent.

Ready-Mixed or Commercial Bait

Ready-mixed or commercial bait is sometimes obtained by the farmers. As a rule, these baits are put up in either 80- or 100-pound burlap bags containing 15 per cent blackstrap molasses, 5 per cent white arsenic, and 80 per cent wheat bran or bran-sawdust mixture in equal parts by volume. It is usually necessary to add approximately 10 gallons of water for each 100 pounds of this commercial bait before it is spread.

Formula No. 1 is recommended for the use of the material supplied by the federal and state governments:

FORMULA NO. 1

Mill-run bran	100 pounds
Sawdust	Equal in bulk to 300 pounds or 3 sacks of bran
Sodium arsenite (4-pound material) (or 3 pounds of sodium fluosilicate)	8 quarts (2 gallons)
Water	40 gallons

(If the sawdust is wet, reduce the water accordingly.)

FORMULA NO. 2

	Large quantity	Small quantity
Wheat bran (coarse and free from shorts)	100 pounds	1 gallon
White or crude arsenic (or Paris Green) (or 3 pounds of sodium fluosilicate)	5 pounds	1 tablespoon
Molasses (blackstrap)	2 gallons	1 teacupful
Water	10 gallons	6 teacupfuls

FORMULA NO. 3

(A small batch of sodium arsenite bait)

Wheat bran (coarse and free from shorts)	100 pounds
Sodium arsenite (4-pound material)	2 quarts
Water	10 gallons

(Sawdust may be substituted for part of the bran in Formulas 2 and 3.)

At the present time Formula No. 1 is the one used most extensively in cooperative campaigns. The bait can be stacked up, and even though it might ferment it is still attractive to the grasshoppers; according to some authorities, more attractive. The bait can be stored for a year or

longer. If it becomes lumpy after being stored, it can be broken up by grinding. Usually, though, if it is moistened in the evening, it will be pliable and ready for spreading in the morning. Badly discolored bait can be used. Poor-looking bait can be mixed 50-50 with fresh bait to good advantage.

Mixing the Poison Bran Mash

If a cement floor or large piece of canvas is not available to mix on, a mixing box 8 feet wide, 16 feet long, and 1 foot deep can be constructed for efficient mixing. Four hundred pounds of bran and sawdust material will measure approximately 6 inches deep in this box.

When mixing according to Formula No. 1, spread the three sacks of sawdust in the box. Then spread one sack of the mill-run bran on top of the sawdust and mix dry. Add the sodium arsenite or sodium fluosilicate and water with a bucket or sprinkling can and mix again.

Obtain a 50-gallon barrel and into this barrel pour approximately 35 gallons of water. Add the eight quarts of sodium arsenite or 12 pounds of sodium fluosilicate for this amount of material. Stir and spread onto the 400-pound bran and sawdust mixture. Do not handle the pure sodium arsenite liquid with bare hands. Large quantities of sodium arsenite are usually placed in 50-gallon steel-drum containers.

If crude or white arsenic or Paris Green is used, as in Formula No. 2, the method of mixing is as follows:

Spread 500 pounds of the bran, or bran and sawdust, in the box. Twenty-five pounds of arsenic or Paris Green, 10 gallons of molasses, and 40 gallons of water should be mixed together thoroughly in a large barrel. This mixture should be stirred continually until the last drop is emptied from the barrel onto the bran. The arsenic is very heavy, so it will settle to the bottom if the mixture is not stirred constantly. Continuous stirring is unnecessary when dry or liquid sodium arsenite is used, as in Formula No. 1 and No. 3, because this substance dissolves quickly in cold water.

If using Formula No. 3, follow general instructions for mixing Formula No.1.

When the mash has been mixed, sack it if it is not distributed immediately, and label it "POISON." Store it where it will be safe. A good supply of large, red tags labeled "POISON" should be at hand at all times for use in marking these poison containers. In control campaigns, color the bait sacks red.

SAWDUST of any kind, with the exception of fresh sawdust from evergreens, may be used. Most of the old sawdust which has been piled out-of-doors for some time is satisfactory. Do not use black, badly discolored, or rotted sawdust. Tests should be taken to see that the sawdust is free from bark, sticks, etc. A quarter-inch screen is commonly used for sifting sawdust for use in grasshopper bait.

ATTRACTANTS such as amyl acetate, orange juice, or salt are not recommended. Experience gained from extensive farm use of grasshopper bait in recent outbreaks and from experimental tests indicates

that grasshoppers in most cases are attracted to the bait without the addition of molasses, amyl acetate, banana oil, citrus fruits, salt, and many other similar substances.

WATER.—Add only enough water to the bait to moisten it, not so much that it becomes sloppy or the flakes of bran stick together. As a rule, 10 gallons of water to 100 pounds of dry material is sufficient.

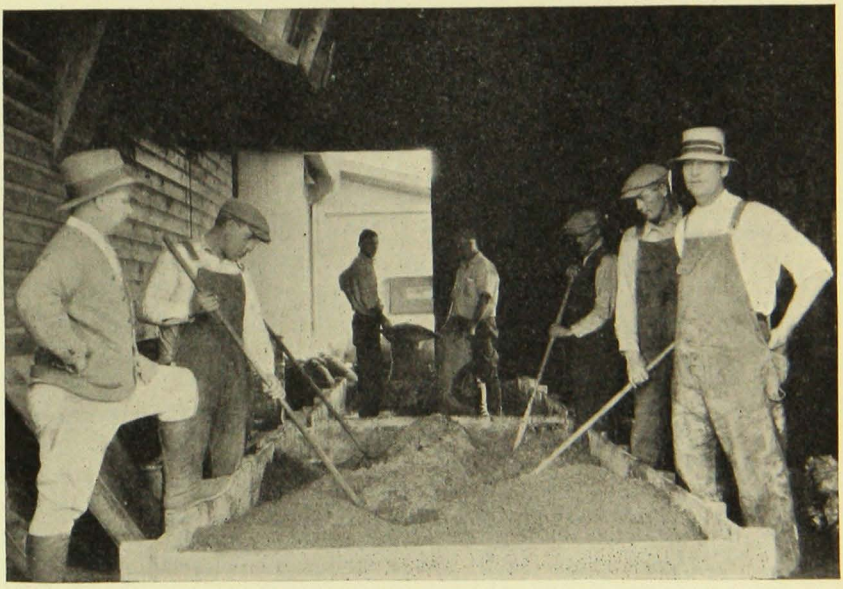

FIG. 5. MIXING STATION, WARREN, MINNESOTA

MIXING STATIONS

When serious outbreaks cover large areas of the county, it is necessary to establish mixing stations in each township so that the material will be readily available to the farmers. In some cases it may even be necessary to establish more than one mixing station in a township. In a number of Minnesota counties during moderate outbreaks it has been found necessary to establish only one central mixing station in the county, usually located in the county seat or in the town where the county agent's office is located. Farmers can come to this mixing station, mix their bait, and take it out to the townships in truckloads as it is needed. Inexpensive mixing machines can be made out of old butter churns and in numerous instances cement mixers have been used to good advantage.

Where one central mixing station is located in the county, it is desirable to establish storage houses for the ready-mixed material in each of the infested townships. The material should be readily available to

the farmers when they need it. When the bait is supplied by the state or federal government, the individual farmer is seldom allowed to take the separate ingredients to his farm and mix them there. In general, the mixing of the poison bait on the farm is dangerous and causes no end of trouble.

Supply of Sacks

In control campaigns where the free bait is supplied, farmers should be told to bring their own sacks in which to place the bait or to exchange for sacks which are already filled with the bait. It is desirable sometimes to set up a revolving sack fund at the main mixing stations so that in case the farmer has not brought bags he can purchase them at cost.

HOW TO SCATTER POISON BRAN MASH

Even where 50 to 100 carloads of poison bran bait were used to a county in the 1932 outbreak, most of the mash was spread by men on foot, scattering the poison from buckets or sacks. It should be broadcast with a snap of the wrist in such a way that it will separate into flakes as it falls. Throwing it into or crosswise with the wind is advisable. More grasshoppers are destroyed if the mixture reaches every square foot of ground, evenly distributed, than if quantities of the mixture only reach every square yard.

Wagons, trucks, and automobiles can be used when large areas or long strips of land are to be covered. A road can be covered in one trip if two men stand at the rear of the wagon or truck and scatter bait on each side. As a rule, a 35- to 50-foot strip can be covered by one man.

Spreading Machinery

Endgate seeders and other similar machinery can be used successfully, but care must be exercised so as not to feed the machine too fast. Plans for homemade spreading machines are available at the State Entomologist's Office, University Farm, St. Paul.

Rate of Application

The bait should be applied at the rate of 20 pounds (wet mash) per acre per application. Too much is applied more often than too little. When properly spread, there should be only a few flakes per square foot.

WHEN TO SCATTER BAIT

The bait should be spread on the hatching grounds after most of the eggs have hatched but before the 'hoppers begin to migrate into the crops. To get the most good out of one application, the spreading should be delayed as long as possible but should be done before dangerous migration takes place. Careful watching and study is necessary during this

stage of the game. Material and equipment for spreading mash should be ready at a moment's notice. Ordinarily 'hoppers do not leave the hatching grounds before they are half-grown. It is this habit which gives us the advantage in control measures. It can readily be seen that this is the important time to poison, when they are in a small area rather than after they have developed wings and are scattered over the whole farm.

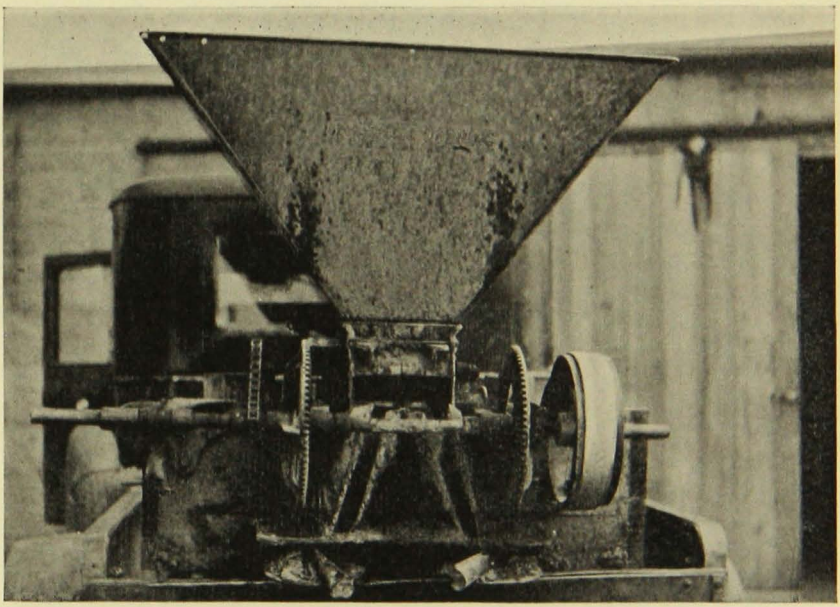

FIG. 6. ENDGATE SEEDER SET UP ON REAR OF TRAILER FOR SPREADING BAIT

WHERE TO SCATTER BAIT

Scatter bait wherever grasshoppers are found. Watch all areas where grasshoppers were plentiful last year. If bait is applied at the proper time, it is necessary to cover only the hatching areas or the egg-infested areas. In trying to locate egg beds and young 'hoppers early in the spring, remember where most of the grasshoppers concentrated in the fall and late summer. Grasshoppers usually are found in pastures, borders of fields, along fences, in alfalfa fields, hay meadows, weedy places, waste land, roadsides, ditchbanks, railroad grades, and, in general, on strips of land 50 to 100 feet wide bordering or near fields which the previous year were in flax, corn, small grains, legumes, and other preferred crops.

When the young grasshoppers are moving, they can be poisoned effectively by scattering strips of mash ahead of them. Where there are large areas of waste land, abandoned farms, or sloughs to contend with,

the least that can be done is to scatter strips of poison bait through these areas about the time the young 'hoppers start to migrate or to delay treatment for a few weeks until they start concentrating. These areas should be carefully watched and treated if there is an abundance of hatching.

TIME OF DAY TO SCATTER BAIT

Grasshoppers do not feed a great deal when the temperature is below 68 degrees Fahrenheit or above 85 degrees. The best time to spread the bait, then, is when the feeding is at its height. The best results are obtained when the bait is fresh and moist. Grasshoppers start feeding soon after sunrise, 5:30 or 6 o'clock, and continue until 10 or 11 o'clock in the morning. It may be generally said that bait should not be put out when the temperature is below 68 degrees or above 90 degrees, or when the skies are cloudy and it looks like rain. Good results were obtained in the Red River Valley, in 1931, when bait scattering started at daybreak and stopped at 10:30 or 11 in the morning. When grasshoppers are migrating, bait can be applied with valuable results at any time.

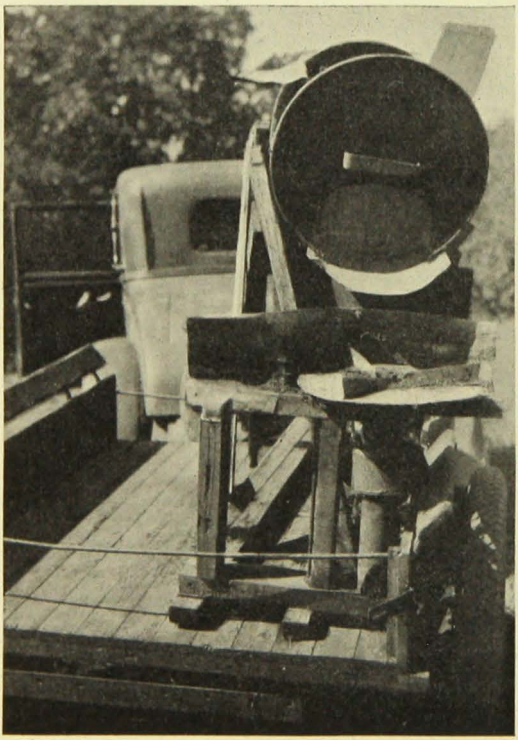

FIG. 7. A HOMEMADE BAIT SPREADER SET ON A TRAILER

EFFECT OF POISON ON THE GRASSHOPPERS

Grasshoppers do not die until 6 to 48 hours after eating the poison, but they do little or no damage after eating it. They usually do not move much more than a rod or two after eating it. Sometimes 'hoppers are hard to find after they die of poisoning, so in estimating the kill the area must be examined very carefully.

DANGER OF POISONING

Always mark or tag bait with the word "POISON." Never leave quantities of the mash where it is accessible to children or to animals of any kind. *Arsenic is a deadly poison.* If the bait is scattered in flakes there is no danger to livestock or birds, but if it is allowed to fall in lumps serious results may follow. Arsenic containers, left-over bait containers, and other similar materials should be burned and the ashes spread very thinly over a large area of ground or buried deeply.

Arsenic dust is poisonous to the lungs if inhaled continuously, and it is also irritating to the skin if allowed to remain on it for a long time. Greasing the hands before handling bait is a good practice.

All cases of livestock poisoning reported to the Division of Entomology are directly traced to *carelessness.* Following our 1932 control campaign in Minnesota, when bait was used over approximately five million acres, the following question was asked farmers and county agents in this area: "Was livestock poisoning due to carelessness, improper application, or handling?" Every one of the 55 counties involved reported that any livestock poisoning was due to carelessness.

Antidotes for Emergency Use in Poisoning

For human beings.—Induce vomiting and give an emetic such as mustard and water at once. Then drink milk and white of egg freely and induce more vomiting. Give hydrated sesquioxide of iron in teaspoon doses. Call a doctor at once.

For domestic animals.—Drench with the following mixture and repeat at intervals:

Ferric sulphate	1⅓ ounces
Water	5¼ ounces
Magnesium oxide	⅓ ounce

Mix ferric sulphate and water and then combine with magnesium oxide. Call a veterinarian immediately.

Effect of Poison on Birds and Other Animals

Extensive experiments have been carried on in studying the effect of these poisons on livestock, poultry, birds, and wild animals. The experiments have furnished conclusive evidence that grasshopper bait, if properly spread, is not a menace to livestock, poultry, song and game birds, and wild animals. There is little if any evidence to support the claim that poultry or birds are poisoned by feeding on poisoned grasshoppers. In numerous experiments, poultry was fed exclusively on poisoned 'hoppers and water for periods of several weeks without any visible effect. Occasionally hunters and others are inclined to blame the reduction of wild game, particularly pheasants, on the use of poison bait

for grasshopper control. Conclusive experiments have been carried on to show that this material can be used at a rate heavier than we recommend without any harm to wild life.

DESTROY GRASSHOPPER EGGS BY WORKING THE SOIL

Plowing, disking, and harrowing will break up the waterproof egg masses and tear them loose from their nesting places in the ground. The idea in disking and harrowing is to bring the eggs to the surface of the soil, where they will be exposed to the drying winds and sun. Many of the eggs are eaten by birds and animals when exposed in this way.

Most of the eggs are deposited in soil that is fairly compact; for example, such areas as pastures, meadows, fence rows, lanes, waste land, abandoned land, ditchbanks, and roadsides. Wherever practical, such places should be plowed to a depth of 6 inches or more. The idea is to bury the egg masses so deep that when the young 'hoppers hatch they will be unable to work their way to the surface. The value of deep plowing will depend a great deal on whether the soil is sandy or clayey and upon the thoroughness with which it has been packed. Deep plowing in the fall, allowing the soil to settle and pack until spring, is better than spring plowing. This applies particularly to sod. Sandy soils naturally should be plowed much deeper than heavy soils to make sure that the young 'hoppers cannot work through to the surface.

Plowing shallow, two to four inches, and thorough disking and dragging afterwards is very effective, provided the disking and dragging are repeated at about two-week intervals until the ground is thoroughly worked up and the eggs are well scattered over and in the surface of the soil.

Egg-infested corn land and grain stubble should be thoroughly disked and harrowed until most of the eggs have been brought to the surface. Work the soil at two-week intervals and cross the fields in different directions each time.

Burning Does Not Destroy Eggs

As the eggs are deposited from one to two inches deep in the soil, burning over the land will have no direct effect on the eggs.

CARELESS HANDLING MAKES POISON DANGEROUS TO LIVESTOCK

If properly spread, mixtures can be applied without danger to pastures where stock is grazing. We have observed chickens feeding on a diet of poison bran mash for several days without harm. Poultry and birds do not seem to be readily affected by poison mash. Seldom, if ever, does a tame or wild fowl pick up enough to cause death.

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