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GRASSHOPPER CONTROL
IN COLORADO

C. L. CORKINS
Deputy State Entomologist



Mixing Ammunition at the Schubert Camp

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GRASSHOPPER CONTROL IN COLORADO

BY C. L. CORKINS
Deputy State Entomologist

Grasshoppers are the most destructive insect pest of cereal and forage crops in Colorado. The average yearly potential loss, if no control measures were taken, is fully \$500,000. This figure does not seem excessive in the light of a conservative crop value of one hundred millions of dollars per annum, which sets the 'hoppers toll at one-half of one per cent. During an exceedingly bad locust year, the possible devastation may reach several millions of dollars.

Grasshoppers in Colorado are just as permanent as agriculture. Certain species have adjusted themselves to our cultural methods and thrive better under our system of farming than under natural conditions. Other species will continue to abound on our non-tillable pasture and waste lands, destroying feed over large grazing areas or even becoming so numerous that they will migrate into cultivated crops. In the face of these facts, all our farmers should consider a knowledge of grasshopper control fundamental to successful farming.

We recognize four factors which make for successful control of a grasshopper outbreak.

- 1—Knowledge of the life history and habits of the species concerned.
- 2—Knowledge of proper control measures and the opportune time to apply them.
- 3—Business-like organization with competent leadership embracing the co-operation of all farmers, enforceable where necessary.
- 4—Adequate funds, efficiently managed, with which to carry on the campaign.

The information herein contained is an enlargement on these points.

FIVE DESTRUCTIVE SPECIES OF GRASSHOPPERS

The life history, habits and control of five of our most destructive locusts in Colorado are alike in so many respects that they may be treated largely in one discussion. The essential differences in their habits are pointed out in the following list:

Mr. Corkins' salary and expenses while securing the data and writing this bulletin were paid from budget of the State Entomologist of Colorado.

Two-Striped Locust (*Melanoplus bivittatus* Say).—The history of this grasshopper over a long period of years undoubtedly proves it to be



Female Two-Striped Locust. Enlarged $\frac{1}{2}$.
Original

the most destructive species known. It has adapted itself admirably to agricultural practices, having selected the alfalfa fields of our irrigated valleys as favorite breeding grounds. Here its eggs are seldom disturbed and the succulent alfalfa is its favorite food, making optimum conditions for enormous increase. Eggs are also deposited freely along ditch banks and fence rows.

From alfalfa fields, the Two-Striped Locust will move into other crops, especially after the first cutting of hay is removed. No crop is immune from attack. Orchards are sometimes completely defoliated, the fruit eaten and the bark of the terminal growth devoured as a last resort. The



Male Two-Striped Locust. Enlarged
 $\frac{1}{2}$. Original

silk of corn is a favorite food, tho the entire plant may be destroyed. Other cereals may be completely devastated or, if in the head, the kernels eaten or clipped. This species is also commonly destructive to vegetable gardens and field root-crops.

Epidemics of the Two-Striped Locust are usually restricted to certain fields or areas. Because of its robust body with relatively small wings inadequate to carry the insect far in flight, widespread migration never occurs. It is only able to move from field to field, marching or jumping combined with some use of the wings while in the air. For this reason one farmer can, with fair success, protect his crops tho his neighbors neglect to kill their 'hoppers.

The nymphs or baby 'hoppers begin to hatch in May, and it is characteristic of this species that the duration of hatching is long extended so that small ones may be found after adults are numerous. Adults may be seen by the middle of June but are not numerous until later.

The distribution is general over all the agricultural areas of the State, epidemics occurring in both the higher mountain valleys and in the irrigated sections of the eastern plains.

Lesser Migratory Locust (*Melanoplus atlantis* Riley).—This grasshopper is a more general feeder than the Two-Striped Locust, being found in abundance on the dry prairie, the uplands, and the valleys as well. However, its greatest damage is done to native pastures and dry-land crops. When severely epidemic, it has not been known to refuse any cultivated plant and will even gnaw dry wood such as fence posts and the handles of farm tools.



The poison is slow in action, dead 'hoppers being found under weeds and rubbish after from two to five days. (State Entomologist's Report, Circular 36.)

Epidemics of this species are often quite wide-spread. Migrations for short distances are also possible, especially when food becomes scarce or tough. For this reason, success in control measures depends upon unity of action by all concerned. Persistent effort upon the part of a few farmers is not without good returns, but is usually very discouraging.

These 'hoppers hatch about the time the spring crops are well up. Usually the majority of the eggs hatch at about the same time, so that control measures should be entered upon before the adults appear. This is especially important when the hoppers are hatching in native pastures, along roadsides, ditch banks or other restricted areas. They should be destroyed before spreading from the smaller breeding grounds to the larger cropped areas.

This is undoubtedly the most generally distributed species of locusts in Colorado. "It may almost be said to occur everywhere up to an altitude of 8,500 feet." (Gillette).

Red-Legged Locust (*Melanoplus femur-rubrum* DeGeer).—This species is found under much the same conditions as the Lesser Migratory Locust. In an epidemic, sometimes the one species predominates and sometimes the other. The Red-Legged Locust differs in habits from the Lesser Migratory Locust mainly in the following ways:

- 1—It seldom migrates, tho it may move from field to field.
- 2—Epidemics are usually local.
- 3—It is commonly more abundant in cultivated fields than in native pastures or uplands.

Differential Locust (*Melanoplus differentialis* Uhl).—In food and migratory habits this species closely resembles the Two-Striped Locust, and is often found interspersed with it. However, its distribution is not so general, being confined to the irrigated valleys of the lower altitudes.

The Long-Winged Locust of the Plains (*Dissosteira longipennis* Thomas). — The Long-Winged Locust of the plains becomes epidemic but very seldom. An outbreak affecting El Paso, Lincoln, Pueblo and Crowley Counties in 1921 was the first of any size since the early nineties. Yet, this infestation, which was some 43 miles long, marks this insect as a serious pest when abundant.

This species is confined to the eastern plains of Colorado, breeding on the native pasture lands. It is indifferent to cultivated plants until it becomes very numerous, at which time it shows little or no preference



Male Long-Winged Locust of the Plains. Enlarged $\frac{1}{2}$. Original



Female Long-Winged Locust of the Plains. Enlarged $\frac{1}{2}$. Original

to them over the native buffalo and grama grasses.

Characteristic of this locust is its migratory habits. Nymphs march in solid armies, hundreds to the square yard; when they become adults and have their wings they take to the air with remarkable ease, and with the aid of the wind may fly long distances. It is therefore imperative to check an outbreak before these 'hoppers reach the adult stage.



Destruction wrought to wheat field by hoppers. Original

LIFE HISTORY

Egg Stage.—Eggs are deposited by mature females, beginning in abundance about the middle of August. Oviposition, or egg-laying, is



Egg Pods of the Two-Striped Locust. Pod on Right With Outer Surface Removed. Enlarged 2 Times. Original

then continued until cold weather prevents grasshopper activity. For egg laying, a rather firm, yet not caked or baked soil, free from stones and roots, is preferred. Hence, cultivated fields are little used. Roadsides, ditch banks, pastures of alfalfa, virgin land and neglected fields are more likely to be selected. However, where 'hoppers are unusually abundant, they will also fill the soil of cultivated fields with egg pods.

Upon choosing a suitable place for oviposition, the female will, with muscular action, work her abdomen into the ground with the aid of horny, sharp projections at its tip. Unless some hard substance is encountered, the abdomen will be inserted its complete distended length, which may be as much as two inches. At the bottom of the hole thus made, the eggs are deposited one by one, pasted together and encased in a frothy, glue-like substance which hardens. The individual eggs are somewhat crescent-shaped, tapering at both ends, cream-white in color and about one-fifth of an inch long. When oviposition is completed, the result is a mass of regularly placed eggs in a slightly curved pod from three-fourths to one and a quarter inches long, the encasement being practically weather proof so long as it remains in the ground. The number of eggs laid in each pod and the number of pods will vary with the individual as well as with the species concerned. There are from two to three pods of fifteen to fifty eggs each per season, making a total of thirty to one hundred and fifty eggs for each female.

None of the adults live over winter to the next spring. All of the five species named pass the winter in the egg stage.

Nymph Stage.—At about the time crops are well up, the nymphs or baby 'hoppers hatch, force themselves out of the egg pod and to the surface of the ground. These nymphs, except for size, the lack of fully

developed wings and a large head in proportion to the body, resemble the adult grasshopper. Upon feeding and growth, they are literally forced to shed their "skin" in order to accommodate the increase in size. To effect this process, which is termed molting, the 'hopper will crawl upon vegetation or some other object and cling with its head downward. The skin then splits over the head and along the back. By muscular effort the 'hopper works its way out, emerging with a larger, yet paler and softer coating. Upon exposure to the air, the new skin becomes hardened and darkened. The cast-off skin remains attached quite firmly to the object upon which the grasshopper was clinging. Farmers seeing these in large numbers will often think them dead 'hoppers and believe that some disease has come to the rescue.

Usually after the fifth molt, the adult stage is reached, in which case the 'hoppers have fully developed wings and are sexually mature. The nymphal period varies from 45 to 80 days, depending upon the species in question, climate, locality, and other minor factors.

Adult Stage.—The adults, some of which appear about the middle of June and are abundant in July, feed voraciously for a period of from two to five weeks. During this time, mating or copulation takes place and the eggs are formed in the bodies of the females. Migration in some species, notably *Melanoplus atlantis* and *Dissosteira longipennis*, may occur during this period.

When the eggs are ready for laying, the females will leave the grain fields in search of suitable places for oviposition, followed somewhat by the males. After depositing one pod of eggs, the females may return to the feeding grounds. Such a movement is not termed migration. This completes the life cycle, which covers a year's time and makes one generation per season.

HABITS

Migratory and food habits have been discussed under each species since they vary somewhat.

Time of Feeding.—The period of most active feeding is during the morning, commencing as soon as the 'hoppers are thoroughly warmed up by the sun and lasting for about two hours. In the lower altitudes of the State this normally begins about 8:00 a. m. and in the higher altitudes about 8:30 a. m., reaching the peak shortly before noon and then rapidly declining. A second feeding begins in the afternoon, about four or five o'clock, but is neither so general nor so intensive as the previous one. During cold or damp weather, the 'hoppers, especially the young, will bunch together in masses in the more open places in the field, upon rocks, clods, or the dryer spots, and do not feed.

Nature of the Injury.—Where the grasshoppers are very abundant, small grains are often eaten to the ground before they have had a chance to gain a good start. Injury on larger plants may vary from partial to complete defoliation, leaving only the tough stalk standing. Even partial defoliation is a very serious handicap to the grain. A large part of the plant food is gained from the air thru the surface of the leaves. Hence, a loss of leaf surface greatly reduces both the quantity and quality of grains.

Especially during a dry season when succulent food is scarce, severe damage may be done by a limited number of 'hoppers upon the heads of grain. Kernels of wheat and barley may be eaten out, or even the heads cut off completely. Oat kernels are often clipped off one by one and dropped untouched to the ground. Prevention of fertilization of corn is often accomplished by the eating of the silk. Such injuries are not apt to be encountered except in the dry-farming regions of the State.

Roosting.—After the evening feeding, the 'hoppers crawl up on vegetation, fence posts, buildings or other objects, with head uppermost, and roost during the night. This is done, presumably, to avoid the dampness of the ground. Nymphs and adults alike participate in this roosting habit.

ARTIFICIAL CONTROL MEASURES

Artificial control measures are those employed by man to check damage. These are largely of two kinds, remedies and prevention.

Remedies—Poison Bran Mash

Of the artificial methods of control, the use of poison bran mash has been proved to be the most practical and efficient. It is now adopted as standard in the United States and Canada. The original Kansas bait has been the basis of many later modifications, so that at the present time, several different formulæ are used. Four are here given which will best meet different Colorado conditions.

Formula No. 1

Bran (free of shorts).....	100 pounds
Crude white arsenic (90 to 98% As_2O_3).....	5 pounds
Salt	5 pounds
Stock molasses (or any cheap grade).....	2 gallons
Lemons (finely ground).....	2 dozen
Water	9 to 11 gallons

Formula No. 2

Bran (free of shorts).....	100 pounds
Crude white arsenic (90 to 98% As_2O_3).....	5 pounds
Salt	5 pounds
Stock molasses (or any cheap grade).....	2 gallons
Amyl acetate, or banana oil (Tech. No. 1).....	3 ounces
Water	9 to 11 gallons

Colorado Grasshopper Bait No. 12

Bran (free of shorts).....	100 pounds
Sodium arsenite (8 pounds As_2O_3 per gallon).....	1 pint*
Salt	5 pounds
Sugar beet refuse molasses (or any cheap grade).....	2 gallons
Amyl acetate, or banana oil (Tech. No. 1).....	3 ounces
Water	9 to 11 gallons

Colorado Grasshopper Bait No. 15

Sawdust	2 bushels
Bran (free of shorts).....	50 pounds
Sodium arsenite (8 pounds As_2O_3 per gallon).....	1 pint*
Salt	5 pounds
Sugar beet refuse molasses.....	2 gallons
Amyl acetate, or banana oil (Tech. No. 1).....	3 ounces
Water	10 to 12 gallons

*Where killing within 24 to 48 hours is desired, use one quart.

Formula No. 1 is rapidly passing out of usage, tho it has been the standard for a number of years. Its only advantage is that lemons are usually easily obtainable, tho they are very expensive, while banana oil may be difficult to procure in a short time.

Formula No. 2 was developed by the Department of Entomology of Montana State College in 1919. The banana oil is at least equal to citrus fruits as an attracting agent and much cheaper and easier to handle. Many of our western states and provinces of Canada have adopted this formula in the past two years. The writer has given it extensive trials under severe epidemic conditions in North Dakota one season and in Colorado two years, with equally as good results as with Formula No. 1.

In using banana oil the following cautions should be borne in mind:

- 1—Procure only pure banana oil which is recommended by College authorities. Grades lower than Technical No. 1, which contain adulterants, cannot be used.
- 2—Banana oil used in excess of the amount given in the formula acts as a repellent. Be sure to accurately measure the exact quantity.

Colorado Formula No. 12 was developed by the Colorado Experiment Station with the idea of obtaining a better killing agent than crude white arsenic. Due to the fact that the arsenic is very heavy and but slightly soluble in cold water, poor mixing very often results. The sodium arsenite used in this formula is entirely soluble in cold water, which means that all particles of water carry exactly the same amount of poison, and that every flake of bran which is moistened is also poisoned. From the standpoint of mixing, it is a "fool proof" killing agent. It is also somewhat cheaper and easier to handle than white arsenic and is fully as efficient.

At the present time, there is still the disadvantage of the inaccessibility of sodium arsenite on the market. The College is doing all possible to remedy this situation and will gladly help the farmers to secure this chemical.



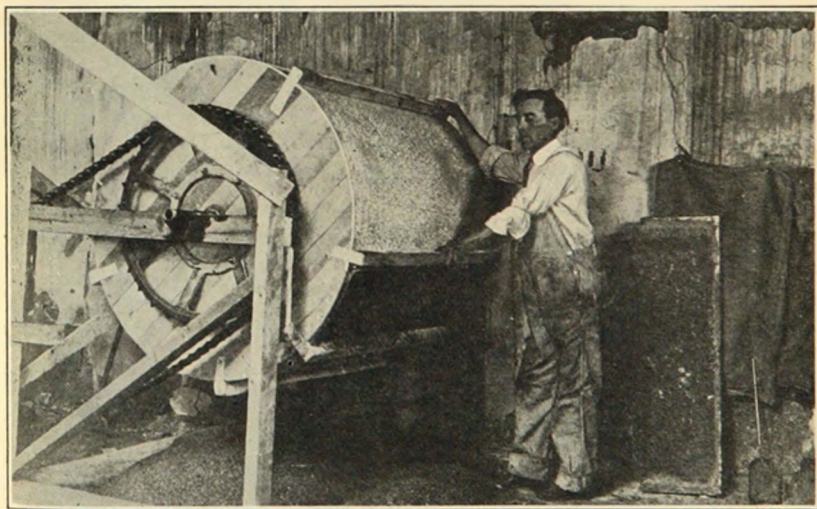
Trucking in bran and other poison supplies for a 60-ton campaign. Original

Colorado Formula No. 15 is given for use principally on pasture lands in the foothills of the State where sawdust may be easily obtained. It will cheapen the use of the bait for these lands and help to make it more practical, from the standpoint of cost, for areas of low production value per acre.

The Bran.—Bran free from shorts should always be used. The gluten in shorts will cause the bran to ball up and stick together upon broadcasting. Most millers of the State have shown a fine spirit of co-operation by running bran free from shorts for this purpose, tho they seldom make it as a commercial practice.

Substitutes for Crude White Arsenic.—In place of crude white arsenic for each hundred pounds of bran, may be substituted four pounds of refined white arsenic or three pounds of paris green. The objection to them is that they are more expensive and no more effective.

The Water.—The amount of water needed will vary with the physical quality of the bran. The coarser the bran, the less the water requirement. The mash should not be sloppy nor even wet enough to stick together. Ten gallons is usually sufficient water for Colorado bran.



Sumpter mixing machine used to mix paris green bran mash, Center, Colorado, 1916. Time required to prepare, mix and sack 100 pounds, dry weight, of the bran mash, eight minutes. (Colorado Experiment Station Bulletin No. 233.)

Mixing the Mash.—Success in using the poison bran mash depends so largely upon the proper mixing that too much stress cannot be laid upon closely following directions, as simple as they are.

Mixing may be accomplished either by hand or by a power machine.

Except for large outbreaks, hand mixing is by far the most practical and will be discussed here.

A building with a tight board or cement floor makes an ideal mixing station. In lieu of this, mixing may be done outdoors on large tarpaulins.

Five hundred pounds of bran may be mixed at one time. The water, molasses, ground lemons (or the banana oil) and salt are all vigorously stirred in a tank or some other adequate receptacle. The poisoning agent is then added and the whole again agitated. If arsenic has been used, great care must be exercised to make sure that it is evenly suspended in the water and none has settled to the bottom. The soup is poured over the bran slowly and mixed in by means of beet forks, shovels or rakes. Five or six mixings from one pile into another will usually be sufficient. If the mash is left to stand, it may be kept without injury for one or two days by covering with wet sacks.

Application.—After mixing, 100 pounds of mash figured on the dry basis, will cover from twelve to twenty acres. The tendency is to spread too much rather than too little. A thin sprinkling, scattered evenly over most of the ground, is desired.

The mash may be applied broadcast by hand from the rear of wagons, buckboards, or even automobiles. It will scatter best if thrown crosswise to the wind. More efficient spreading may be accomplished by the use of a large end-gate seeder. The mash must be fed into the hopper a handful at a time, else choking results. Special apparatus built upon the same plan as an end-gate seeder, but with a larger throwing disc and a faster gearing, may be constructed from cast-off machinery by the ingenious farmer. Such has been used with remarkable success.



Hand spreading demonstration. (Colorado Experiment Station Bulletin No. 233.) Jones

The time of feeding is the safe guide for the time of application. **Poisoning should, therefore, be done in the morning only, from eight o'clock until noon, or shortly thereafter.** Mash put out earlier in the morning will be dried up and caked together by the sun before the 'hoppers are active. Not only from the standpoint of a lighter feeding, afternoon poisoning often fails because of sudden unforeseen showers.

The number of applications will vary. One is seldom sufficient. Two or three are usually necessary.

When to Begin Poisoning.—In this combat, procrastination is very often the locust's victory. The first hard and fast rule of the game is to prevent 'hoppers from gaining access to the small grain fields, especially if the plants are tall and thick enough to completely shade the ground. Poisoning in heavy wheat or oats is very discouraging. It should be done before the nymphs leave their hatching beds on waste lands, ditch banks and roadsides.

In the case of an infestation of the Two-Striped or the Differential Locust, where they have hatched in alfalfa fields, it is usually wise to leave poisoning operations until after the hay is cut and raked. Very little damage is likely to be done to the first cutting. Neither are they apt to migrate from alfalfa fields to other crops. One exception to this is the case where small grains are on the border of the alfalfa, in which event a swath of hay about two rods wide should be kept mowed down and occasionally poisoned.

Cost.—The cost varies with so many factors that it is difficult to get accurate figures. Computing on the basis of the average of several large campaigns, it will approximate about 40 to 50 cents per acre for both material and labor.

On native pasture lands where one application of Colorado Formula No. 15 is commonly sufficient, the cost, including labor, will average about 20 cents per acre.



Part of 553 hogs grazing on alfalfa after paris green bran mash had been sown to control grasshoppers at the rate of eight pounds per acre. No animals were poisoned. C. R. Jones. (Colorado Experiment Station Bulletin No. 233.)

Stock Poisoning.—If the bran mash is mixed and spread according to directions, there is no danger of poisoning either stock or fowls. In the writer's experience in large campaigns in three different states, he has not known of the loss of any animals except from carelessness around the mixing vats. The only caution is to exercise great care in keeping all mixing utensils away from children and domestic animals.

Spraying with Insecticides

Spraying with insecticides usually does not give much relief. Of these methods, spraying with kerosene emulsion along roadsides or on other waste lands soon after the 'hoppers have hatched and before they begin moving to the fields, probably gives the most satisfactory results.

It should be stated, in order to avoid unnecessary expense, that spraying with arsenicals, such as paris green or arsenate of lead, has almost invariably proved a failure.

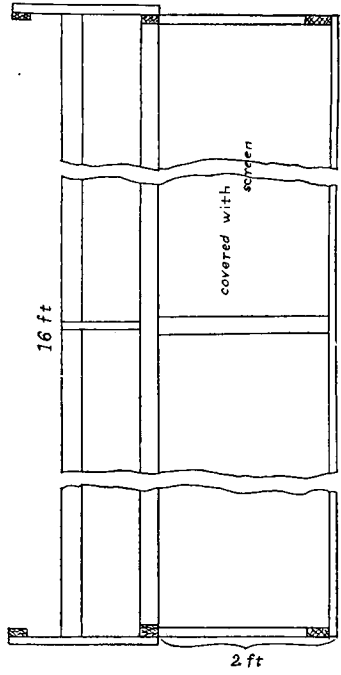
Hopper Dozers*

The use of the "hopper dozer" is so well known that it needs but passing mention. Two variations in the common method of locomotion might well be mentioned. One is the mounting of the dozer on the teeth of a bullrake, thus giving vertical adjustment for use in running over tall alfalfa or other fields. The other is a small, 12-foot dozer, detachably mounted on the front of a "flivver." Such an apparatus is very successful in the point of saving time. It should be used just before evening when the 'hoppers are still quite active or in the morning when they begin to move about.

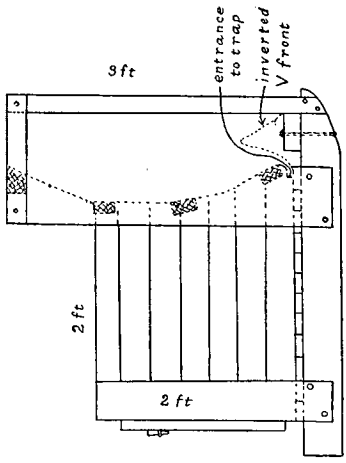
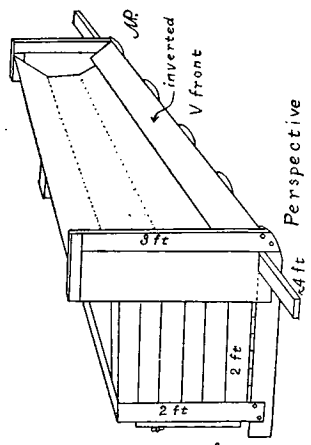


A 'hopper dozer' in action. One of the many machines that was used in the grasshopper campaign, 1916, San Luis Valley. (Colorado Experiment Station Bulletin No. 233.) Jones.

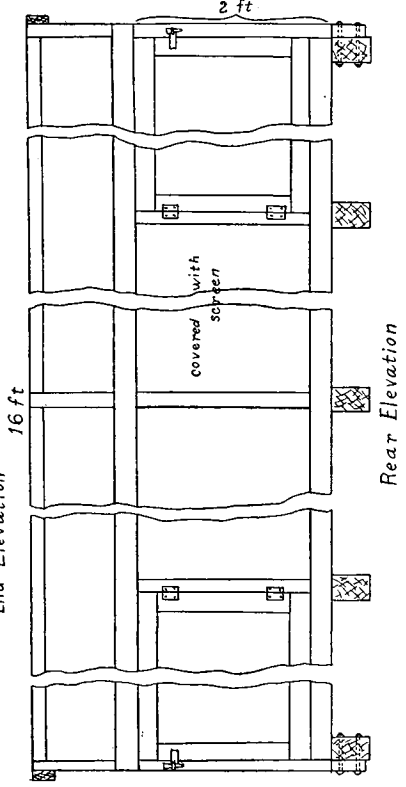
*For directions in construction and use of 'hopper dozers and catching machines, see "Grasshopper Control," Bulletin 233, Colorado Agricultural Experiment Station, by C. R. Jones.



Top Elevation



End Elevation



A detailed diagram of a grasshopper catching machine. (Colorado Experiment Station Bulletin No. 233.) Jones

Grasshopper Catching Machine

The grasshopper catching machine, designed to catch live 'hoppers, was successfully used in Colorado in 1902. Similar machines have given good results in Utah, New Mexico, Montana, North Dakota and other states. These have two distinct advantages over the "hopper dozer," namely, they may be used on rough ground, and the hoppers may be saved, dried and used as winter chicken feed.

In the event that hoppers are used as chicken feed, they may be scooped into sacks, thus left for two days or until dead and then spread out to dry on a tarpaulin in the sun. Otherwise, they may be killed in the machine by spraying with kerosene.

PREVENTION

Methods discussed under this heading are designed to work along the lines of the old adage that "an ounce of prevention is worth a pound of cure." In the case of grasshopper control, this may not be literally true, yet some measures of prevention can well be employed. Where intensive agriculture is practiced, these methods are of the most value. They cannot be said to be practical where egg beds cover vast areas of waste land.

Of these measures, late fall or early spring plowing to the depth of six inches is most sure. It should be understood that this method works by burying eggs so deeply that the young 'hoppers cannot escape upon hatching. Therefore, shallow plowing or failure to turn the furrow under is ineffective. If the soil is sandy and light, it should be well packed after plowing to prevent the 'hoppers from working thru.

Thoroughly discing the ground three ways, lengthwise, crosswise and cornerwise, in the fall has been effective in many cases. Such a procedure breaks up the egg pods, smashes or exposes the eggs to the elements or natural enemies. The greatest objection to it is that few farmers will do the work thoroughly enough to get results.

NATURAL CONTROL

Insect Enemies.—It is very often the case that a season of heavy grasshopper damage is followed by a year of little or no injury. Such a phenomenon may be due to the fact that insect enemies have become so numerous as to hold the 'hoppers in check. Of these, a group of flies known as the Sarcophagids are perhaps the most important. They resemble the house fly somewhat in size and general appearance, tho some are larger. When numerous, these flies may be observed to dart at the 'hoppers as soon as they stir. They do this to deposit, either an egg or a living maggot. If an egg, it will soon hatch into a maggot which enters the body cavity and lives upon the internal organs. One maggot is sufficient to so devitalize a female 'hopper as to prevent egg laying. When fully grown, the maggot will leave its host and enter the ground for pupation. Their average life cycle is about three weeks, so that several generations a season are possible.

Among the insect enemies of grasshoppers are other parasitic flies, ground beetles, robber flies, blister beetles and wasps.

Locust Mite (*Trombidium locustarum*).—Closely related to the insect enemies is the Locust Mite. This

mite, which is red in color, is often seen in great abundance attached to all parts of the 'hopper's body. However, the most severe damage that the mite commonly does is to lessen vitality and occasionally distort the shape of the wings. The writer has observed migratory locusts that have flown for many miles while infested with as many as a half dozen of these mites with no apparent handicap. The farmer often hails the appearance of these parasites as the end of his troubles, only to be met with disappointment.

Fungous Disease. —

There is a fungous disease (*Empusa grylli* Fres), which has been known to kill large numbers of locusts in Colorado and other states. However, its appearance is very erratic, the good done often localized and the period of heavy killing very short.

The first characteristic symptom of this disease is



Grasshoppers killed by *Empusa grylli* Fres clinging to oat heads, Trinidad, 1916. (Colorado Experiment Station Bulletin 233.) Jones.

the tendency of the infected 'hopper to climb up the stem of some vegetation, attach itself head uppermost in a death-like grip and with the hind legs akimbo. The body soon becomes somewhat softened and distended, due to the growth of the fungus. With death, the 'hopper blackens and remains attached in the characteristic position.

Attempts at artificial spreading of this disease have given no satisfactory results.

Birds.—Many birds have more or less of an insectivorous habit. Even those birds that we think of as seed or vegetable eating, or as scavengers and birds of prey, will, in the presence of an abundance of insect food, break away from their normal habits and take that which is at hand in abundance. Thus, in the history of large grasshopper outbreaks, many other than the commonly insectivorous birds have been noted as accomplishing much good. However, it should be emphasized that birds are of the greatest importance as constant, rather than sporadic consumers of insect life, and as such do much to maintain the balance in nature.



Chickens in the field used as a method of control for grasshoppers, 1916, San Luis Valley. They did very efficient work immediately around the portable coop, which was moved every other day. (Colorado Experiment Station Bulletin 233.) Jones.

ORGANIZATION FOR CONTROL MEASURES

By taking advantage of the Amended Pest Law*, Colorado farmers are fortunate in being able to have a very efficient basis for grasshopper control. Without such a law, the more progressive farmers usually take all the burden and suffer reinfestation from their less progressive neighbors. To make control measures successful, it is necessary to have volunteer co-operation of the majority of the people interested and compulsory action of the others, including the non-resident land owner. The office of the State Entomologist will gladly co-operate with the various communities infested with grasshoppers in effecting a working organization.



All day picnic organization meeting for grasshopper control. Original

*See "Colorado's Amended Pest Law," State Entomologist Circular No. 32.

FINANCING A GRASSHOPPER CAMPAIGN

The matter of adequately and efficiently financing a grasshopper campaign so very often depends upon local conditions that it is impossible to make any specific recommendations. Considerable experience with this problem suggests two principles which seem fundamental and may be of some service:

First—In an extensive grasshopper outbreak, it is economically fair and just that all of the residents of that territory share some of the financial burden. Since farming is the basis of all industry, it is reasonable to expect that heavy crop losses over a large area will also seriously affect business and professional life closely associated therewith. For this reason, county officials should feel morally and legally justified, as an emergency measure, to use funds secured from general taxation for the alleviation of widespread insect depredations.

Second—Each and every farmer benefited by outside financial assistance should also personally share at that time a goodly portion of the expense of poisoning operations on his own premises. If the land owner is furnished all of the poisoning supplies by the county and feels no direct connection between it and his bank account, very often waste results. But, if he has just paid half of the cost out of his own pocket, there will be a potent incentive to use these materials more economically and efficiently.