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**Methods of Controlling Grasshoppers.**

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MANHATTAN, KANSAS.

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## SUMMARY.

GRASSHOPPER injury to crops in Kansas is done only by native species. The amount of injury is likely to increase as more of the prairie region is brought under cultivation, as the climate is favorable to their development.

Most of the damage can be prevented if proper control measures are introduced into the regular farm practice. These control measures consist of the destruction of the eggs by plowing and disking, and of the destruction of the young and adults by the use of poultry and hogs, the hopperdoxer, the poisoned bran mash, or by burning where there is sufficient vegetation to carry fire.

The poisoned bran mash has been thoroughly tested and can be relied upon wherever it is applied with the same intelligent, persistent effort which a successful farmer devotes to his other farming operations.

Stories of the poisoning of stock, upon being traced to their origin, have always proved false, or else have resulted from improper application or careless handling.

Wherever poultry and hogs have been given a fair trial they have always checked grasshopper outbreaks. The uniform success that has attended their use in different sections of Kansas makes seem surprising that they have not been more widely employed against these insects. On many Kansas farms enough young poultry is raised annually to catch many times the number of grasshoppers that hatch on the place. For this purpose it would require handling in a portable house, but the money invested in such a structure would be a low rate of insurance against grasshopper injury.

The facts presented in this bulletin will enable any farmer to prevent much of the damage usually done to his crops by native grasshoppers. As a pest, the insects can be entirely eliminated in any community by concerted action among the farmers and landowners.

# Methods of Controlling Grasshoppers.

By F. B. MILLIKEN.<sup>1</sup>

## INTRODUCTORY.

The investigations reported in this paper were made in July, August and September, 1911, with headquarters at Dodge City, and in July and August, 1912, with headquarters at Garden City. During the first summer Pierceville, Garden City, Scott City and Winona were visited, and outbreaks at Greensburg and Kiowa were investigated in the summer of 1912.

### History and Distribution.

The grasshoppers doing injury in Kansas during the period covered by these investigations are of native species. Before the settlement of the country they probably bred only in places that produced enough food for them, such as creek bottoms. With the settlement of the country, the introduction of dry-land farming and the development of irrigation they spread through all sections of the state. They have followed the plow, and are now found nearly everywhere that cultivation is attempted. The introduction of the Russian thistle in the western part of the state has provided food for them in places where they have never been able to survive before.

### Species Doing In jury.

Although more than thirty species of grasshoppers have been collected by the author in this region since these investigations were completed, only four species have done any considerable damage. These were the differential, the two-lined, the lesser migratory and the Bruner grasshoppers. The Carolina grasshopper is frequently seen throughout the state, but has not injured crops during the period covered by these observations. Other species have been present in different parts of the state in sufficient numbers to add to the general

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1. The manuscript for this bulletin was originally prepared in September and October, 1911, but the number of other bulletins then in the hands of the state printer prevented its publication. The author is now employed by the United States Department of Agriculture. Now that it has become possible to publish it, revision is desirable, and the author is able to do the revising through the permission of the department officials.



given before March 1, so that there will be considerable freezing and thawing afterward. A much greater number of eggs will be destroyed if the egg-infested land is disked during October or November, then harrowed during the first spring thaw. The harrowing treatment will break up capsules that were missed by the disking and expose some eggs that were sheltered before.

**Destruction of the Young and Adults.**

BURNING.

Where large numbers of young hatch in grass or weeds that will carry fire, burning is the quickest and surest means of destroying them. Abandoned fields, roadsides, fence rows and weedy parts of pastures can be treated by this method. In places where vegetation is scanty some old hay or straw will help to carry the fire. The burning should be done when a brisk wind will sweep the fire rapidly over the ground, thus overtaking any grasshoppers that try to escape.

THE HOPPERDOZER.

The hopperdozer is a device for catching grasshoppers in oil or tar. It consists of a shallow pan mounted on a low sled, with an upright screen at the back to catch any grasshoppers that try to fly over it. The common type of pan is made by

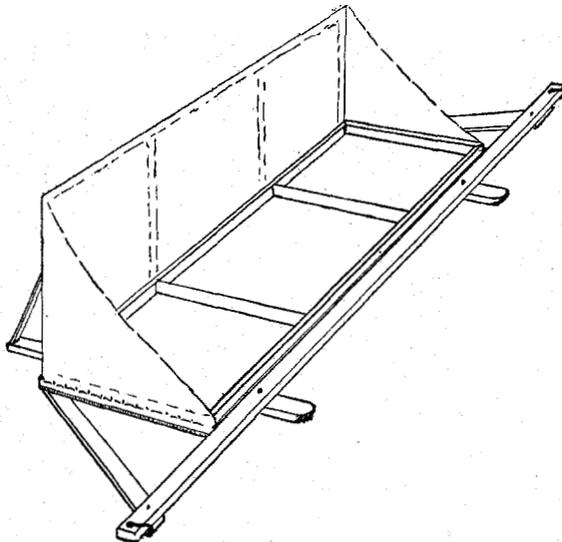


FIG. 2. A hopperdozer.  
(From Farmers' Bulletin 691, U. S. Dept. Agr.)

turning up six inches around the edge of an eight-foot sheet of galvanized iron. Two inches of the edge is then turned down over the pan to prevent the liquid slopping out, and two partitions soldered across it to prevent the liquid running to one end and spilling when the pan is used on hillsides. The details of construction for the sled are indicated sufficiently in Fig. 2. The screen at the back is of oilcloth with the smooth side forward.

When the hopperdozer is ready for use about one inch of water is poured into each compartment of the pan, and enough kerosene or crude oil added to form a film over the water. If tar is used a layer is spread on the bottom of the pan. Many grasshoppers jump out after getting into the pan, but if smeared with oil or tar they die. Those that remain in the pan must be removed at intervals and more tar or water and oil added.

Sleds for hopperdozers are usually made to carry two pans set end to end, thus covering a strip 15 feet wide. When drawn by a horse hitched at each end it covers the ground rapidly. Where large areas of level land are to be treated, two or three of the pans are sometimes mounted on the teeth of a sweep rake, but the wheels of the rake jolt the pans badly on rough ground. In such places two sleds, each holding two pans, are set end to end. The sleds are then bolted loosely together through the runners, with a 2 by 4 between them. The 2 by 4 should project 4 or 5 feet to the rear. From the end a heavy wire should be stretched tightly to the outer back corner of each sled. This wire braces the double hopperdozer so it may be drawn by a team hitched at each end. The screens at the back of the sleds must be arranged so as not to interfere when the outer ends are higher than the middle.

#### POISONED BRAN MASH.

A bait of bran and white arsenic or Paris green, mixed and wet with water, has long been used for poisoning grasshoppers. The usual method of application was by placing it in balls or heaps about the edges of fields in places where grasshoppers were doing injury. During the investigations at Dodge City in 1911 the writer tested many formulæ for making the bait and many methods of applying it. A bait containing enough finely-chopped oranges or lemons to give

it a strong fruit odor was found to be the most attractive to grasshoppers, and it attracted the greatest number when sown broadcast early in the morning or late in the afternoon. Broad-casting the bait also made it impossible for poultry, other domestic animals or wild birds to pick up enough to be injurious.

The exact quantity of each active ingredient used in the bait is immaterial, but since in broadcasting the bait it goes a long way, it is better to have a slight excess of these rather than not enough. Only as much water should be added as will be readily absorbed without draining off and wasting the poison. Lemons are preferred to oranges, but the choice should be governed by the prices of the two fruits, selecting the cheaper. The quantities of ingredients given in the formula are those most conveniently handled under the usual farm conditions.

Bran .....	20 pounds
Paris green or white arsenic.....	1 pound
Syrup .....	$\frac{1}{2}$ gallon
Lemons or oranges .....	3 gallons
Water .....	$3\frac{1}{2}$ gallons

Mix the dry bran and poison in a washtub or a tight box. Mix the syrup, the finely chopped pulp and peel of the fruit in the water. If the bait is not to be applied immediately, only about three gallons of the water should be used, but the remainder should be added before the bait is spread. Then pour the liquid over the mixture of bran and poison, stirring with a spade, a wooden paddle or a shingle to dampen it evenly.

While fresh this wet mash flavored with fruit juice is very attractive to grasshoppers, but when dry or stale it is not eaten. The amount prepared by using 20 pounds of bran will sow 5 or 10 acres, depending on the number of grasshoppers present. It should not be sowed just before a shower, as the rain washes the poison from the bran, leaving it harmless. Little of the bait is eaten after the second day, even in damp weather; therefore, several applications may be necessary to check damage in badly infested fields or to keep injurious numbers of grasshoppers from drifting into a field.

Where bait is to be spread on fields of a few acres it can be carried in a pail on the arm; but when spread on large areas or on long strips in the edges of fields or pastures or along roadsides it should be carried in a tub or box on a sled

or in an open buggy. One man can both drive and sow the bait.

Large amounts of this bait have been used by broadcasting. In 1913 about 1000 tons of the poisoned bran mash were used in Kansas. Not even wild birds were killed. Cases of poisoning that have been reported have proved to be due to careless application or handling. Much of this bait has been used in New England, New York, Virginia, Florida, California, Colorado and Canada, and in every case emphasis has been placed on the absence of poisoning among domestic animals and birds. However, a few cautions will not be out of place.

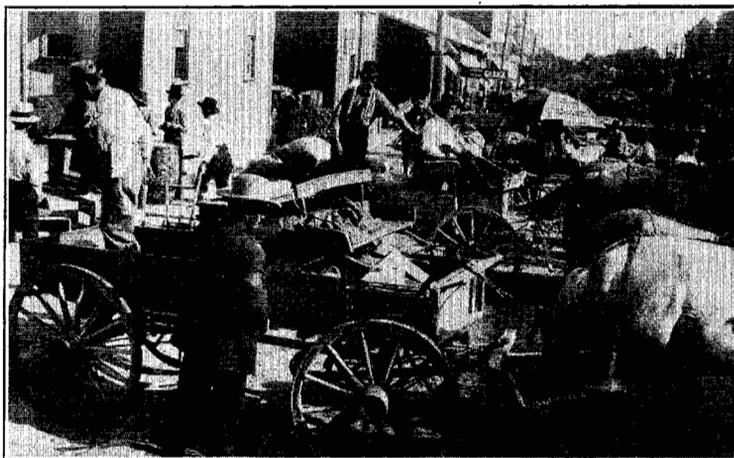


FIG. 3. Distributing the poisoned bran mash at Dodge City, Kan., during the grasshopper campaign of 1913. (After Dean.)

The bait should never be placed in heaps or scattered thickly. The poison and mixed bait should be kept out of the reach of children, poultry or domestic animals. Utensils used in the preparation of bait should be thoroughly scrubbed before being used for any other purpose. The dry, powdery poisons should never be exposed to the wind or handled roughly. If the hands are used in mixing the bait enough poison may be absorbed through the skin of the hands and forearms to cause severe intestinal cramps and diarrhœa. However, the mixed bait can be sown from the bare hand without danger of poisoning. Grown poultry can run without danger where not more than 4 pounds of bait per acre has been scattered, but chicks or small turkeys should be kept away until the scattered bait has dried.

OTHER POISONS.

The criddle mixture (bait in which horse dung instead of bran is used) has been repeatedly tested, but without success. Arsenite of soda solution is not a practical poison against native Kansas grasshoppers, because they do not move about enough. Dusting poison directly on dewy vegetation has given excellent results in some instances, but can not be recommended for application on a large scale.

UTILIZATION OF POULTRY AND HOGS.

In 1911, Mr. Coffin, of Scott City, had the second crop of 160 acres of alfalfa badly damaged by grasshoppers. After the damaged crop was removed he turned 100 turkeys into the field. When the field was visited during the last week of August the only grasshoppers in it were a few of the lesser migratory that had escaped capture by flight.

In 1912, G. Maune, of McCue, raised 140 turkeys, whose range included 135 acres of alfalfa, 35 of which were left for a seed crop. The seed crop on other fields in that vicinity where no turkeys ranged was entirely destroyed, but the 35 acres set a heavy crop of seed.

In 1912 a portable henhouse was constructed in which to keep about three dozen hens on a hopper-infested alfalfa field. The house was located in or near the edge of the field, being moved at intervals. Large numbers of grasshoppers were caught, and the chickens acquired a taste for insects that led them to wander far afield when the house was returned to the barnyard,

At Garden City, Kan., in 1913, Mr. Halsey had some rhubarb which was being badly damaged by young grasshoppers. Three hens with about forty active chicks were placed near it. The hens were shut in coops and the chicks allowed free range. Three days later the grasshoppers on the rhubarb had all been caught, and the chicks were catching others in adjacent parts of the garden. During the same year the Garden City branch of the Kansas Experiment Station bought several hundred young chickens for catching the grasshoppers that were in their crops. The chickens were housed in a portable structure, a wooden framework on low trucks. Poultry netting was nailed on the outside of the studding of this framework and canvas on the inside. The building was easily hauled by team from place to place. Handled in this way the chickens

were considered the most effective means for destroying grasshoppers that was tried that year.

In 1911, Mr. Albert Miller, of Dodge City, let some alfalfa stand for a seed crop. In one corner of the field was a lot in which several hogs were kept. The grasshoppers damaged the entire field except the hog lot, in which a good crop of seed was set.

In 1912, Mr. Niquette, of Garden City, ran 100 head-of hogs, mostly spring pigs, on 160 acres of alfalfa. They were given the run of the field before the alfalfa became green in the spring. Though abundant all around the field, grasshoppers damaged it only on the side farthest from the feed yards. In the evening the hogs would forage along the edge of the field, picking up the luckless hoppers that had strayed into it,

The instances cited are sufficient evidence that poultry and hogs, when given the opportunity, are capable of devouring large numbers of grasshoppers. Many others are driven away by the disturbance incident to a flock of chickens or turkeys, or a drove of hogs, catching what they want to eat. The result is that any area over which these animals habitually range from early spring is soon almost entirely free from grasshoppers, even in the years of severest outbreaks and remains free throughout the summer. When an outbreak is neglected until the grasshoppers are mature before the animals are given access to them the latter are likely to overeat. However, their appetite for grasshoppers is only temporarily affected, and gradually returns until the insects are almost their only article of diet.

Any active poultry will catch grasshoppers, but if raised for this purpose should be handled with as little expense as possible. Only enough grown fowls should be wintered to serve as breeding stock, the remainder being sold as soon after grasshopper danger is passed as a profitable market can be found. Keeping them longer necessitates additional grain feeding, and this in the semiarid region is expensive.

The chicks or poults should be hatched with the first seasonable weather and be ready for catching grasshoppers while the latter are yet small. This is the time when the number of insects can be reduced most rapidly, and young poultry is more voracious than the older fowls. Newly hatched grasshoppers

are too small to attract large chickens and turkeys, but they must be caught early, else they will develop beyond control.

Chicks for catching grasshoppers should be hatched in comfortable quarters, then transferred to a portable house as soon as they can get along at night without the care of the hen. A portable house can be constructed on low wheels or on a sled with high runners, such as 2-by-10's or 2-by-12's set on edge. It should be light enough to be drawn by one team, but strong enough to provide shelter during storms and to protect the fowls from attacks of coyotes, skunks, stray dogs and similar enemies. Various styles of construction meet all requirements. The floor can be made of this lumber, with sleepers close enough together to give the necessary strength. The framework for the walls and roof should be strongly braced, as such structure is likely to be racked by hauling and by winds. The sides should be boarded up with thin lumber to a height of about two feet from the floor. To make the remainder of the walls the studding should be covered outside with poultry netting well nailed on, and inside with canvas. The canvas should be nailed on through lath or other thin strips of wood. The walls need be only about three or four feet on the low side and one foot higher on the high side. Ventilation through the canvas walls will be sufficient. The door can be small, only large enough to permit of cleaning the building. The roof may be of inch lumber with the cracks battened, or of thin lumber well covered with prepared roofing. Strong guy wires should be securely fastened on the corners, and the building kept staked down at all times.

By boarding up the remainder of the sides of such a house as is described above it can be made warm enough for housing the grown fowls through the winter. When constructed with the intention of using it for this purpose the roosts should be arranged to fold up against the walls, thus making it easy to clean. Some provision should also be made for nests.

Young turkeys can be sheltered in a portable house until they are hardy enough to roost in the open; then elevated roosts should be provided on the outside of the building. Turkeys instinctively roost outdoors, and often disagree with their owner as to what is the best place. In a hopper-infested community, however, the wise man with a flock of turkeys will come to terms with them some way, and afterward adopt

whatever measures are necessary to protect the flock from skunks and coyotes. If no trees are near they can usually be induced to roost on a wagon box, a hayrack or on some of the farm buildings. It may sometimes be advisable to erect a woven-wire fence around their roosting place. If the area to be protected from grasshoppers is so large that enough turkeys are kept to require a herder they will soon become accustomed to being driven home to roost. In such cases it may be found profitable to erect inclosed roosts on different parts of the farm, and then drive the flock at night to the nearest roosting place.

Hogs of all ages will catch grasshoppers, though large pigs and shoats are best. However, as less capital is required to raise poultry than to raise hogs, the former are usually the more profitable when raised primarily for that purpose.

### **Protecting Sugar Beets, Truck Crops and Gardens.**

Most of these crops require cultivation which leaves the ground unfit for egg-laying. This is true of all that require cultivation until midsummer or later. With some the soil is stirred so much by harvesting that not only is it unfit for egg-laying that fall, but any eggs already in it are likely to be destroyed. Sugar beets and potatoes, both Irish and sweet, belong in this class.

Injury to truck and garden crops by grasshoppers is always from invasion by insects that breed in surrounding land, and control measures must be directed to destroying them in their breeding places as well as to preventing invasion. Gardens that lie in the range of farm poultry, and are fenced, are usually kept free from grasshoppers through the work of the fowls. In other cases the garden is so located that measures applied to protect other crops protect it also. Where not protected by these or other factors in their surroundings, garden crops are likely to be the first to suffer from grasshopper attacks, and their comparatively high value should lead not only to persistent application of poisoned bait in the garden, but also to a determined effort to free the surrounding land from the insects.

Sugar beets are sometimes attacked when first coming through the ground, and entire small fields, or wide strips along the edge of larger ones, eaten bare before the injury

is suspected. Poisoned bait should be spread, beginning a little in advance of the line of injury and working toward the edge. The insects must also be destroyed on the surrounding infested land.

#### **Protecting Orchards.**

Poisoned bait for orchards may be prepared by adding one pound of quicklime and one-half gallon more syrup for each twenty pounds of bran used. The syrup makes the bait adhere to the foliage and the lime prevents burning. The lime should be slaked and the syrup and enough water added to make three and one-half gallons of liquid for each twenty pounds of bran. The resulting bait should be thrown forcibly into the tops of the trees.

If the orchard is included in the range of a flock of poultry or a drove of hogs, not enough grasshoppers are likely to get into the trees to do much injury. However, the animals must have the run, not only of the orchard, but also of a considerable area surrounding it in order to be able to catch the grasshoppers before they enter the trees.

#### **Protecting Corn and Similar Crops.**

Crops grown on land that receives summer tillage are usually injured only through invasions from adjoining infested land. Control measures must be directed not only to the protection of the crop, but also to the destruction of the insects on their surrounding breeding grounds. Some poultry or hogs running in the corn, or any other crop which they can not injure, will do much to free the fields of grasshoppers. Their use and the use of the poisoned bait on the surrounding infested land soon reduces the number of grasshoppers until no further damage is done.

If the poisoned bait is to be used in fields of corn or other similar crops it should be prepared as directed for use in orchards. Then much of it will adhere to the blades, where it will be found immediately and eaten by grasshoppers.

#### **Protecting Small Grains.**

Late in the fall grasshoppers often damage wheat, eating off the green spears as they appear. The insects collect in weeds or other vegetation along the edge of the field to roost at night, and go out on the field to feed during the day.

Some growers have found that mowing the weeds along the edge drives away the grasshoppers. Having the fields free from weeds at seeding time also does much to keep them away. Where they drift into a field after seeding, or collect and roost along the edges, the poisoned bran should be applied as many times as is necessary, at intervals of two or three days, until the damage is checked. The bait should be applied at about the time of day that it becomes warm enough for the insects to begin feeding.

In the spring small grains may be attacked at any time before harvest, and just before harvest the insects can do the greatest damage. Before the wheat begins to fill poultry can be used to advantage. After the grains from the fowls are likely to pull down many heads. The poisoned bait should then be used. In 1913, at Garden City, bait was scattered in the edges of fields of small grain to kill grasshoppers that were invading beet fields. In places the ground soon had on it as many as ten dead grasshoppers per square foot.

### **Protecting Alfalfa.**

An alfalfa field is one of the best breeding places for grasshoppers. It provides food from the first growing weather in the spring until the ground freezes in the fall, as well as a compact soil for egg-laying. Alfalfa fields that contain eggs should be disked early in the winter and harrowed about March 1. The edges and weedy or grassy patches through the field should receive this double treatment, because they are always the worst-infested spots. Adjoining fence rows, roadsides and the banks of ditches through the fields should, wherever possible, be given treatment to destroy the eggs. If the eggs are not destroyed plans should be made to have poultry or hogs range over the field or to scatter the poisoned bran mash. One application of the bait immediately after a crop has been cut often kills most of the grasshoppers. At other times two or more applications at intervals of two or three days are required.

In 1911 the writer, working on the farm of Mr. Geo. West, of Fort Dodge, conducted a test in which a plot containing approximately  $6\frac{1}{4}$  acres was treated with the poisoned bran mash, and the yield of hay compared with the yield from a check plot of the same area. The treated plot received four applications of the bait at the rate of 4 pounds per acre, and

same was scattered around its edges at another time. The total cost was 86 cents per acre, or 20 cents per application. The yield was 3330 pounds per measured acre, which sold for \$15.67. The yield from the check plot was 2940 pounds per measured acre, and sold for \$13.96. This gives a difference in favor of the treated plot of \$1.71 per acre, or twice the cost of treatment.

Serious injury is frequently done to young alfalfa. As a seeding represents a comparatively heavy investment of both money and labor, every effort should be made to save it. The field should be free from weeds when seeded, to insure its being free from grasshoppers. The insects on adjoining fields should be killed by a persistent application of the poisoned bait, or caught by poultry and hogs where these are available, and the bait should be applied at intervals of two or three days on the edge of the field to be protected until danger is passed.

### NATURAL CHECKS.

#### Moisture.

Kansas soils are so well drained that grasshopper eggs deposited therein are not often injured by too much moisture. Only in the heavier soils in the eastern part are many eggs destroyed, even in very wet years.

The dry, windy weather which usually prevails throughout the state during the spring and summer is very favorable for grasshopper development. Wet weather causes disease among them. Heavy rains sometimes bury the young so deep in mud that they cannot escape. However, they are not easily drowned. Fifty per cent will revive after eight hours immersion. Immersion for more than twenty-four hours is required to drown all of them. Both young and adults may be carried several miles by flood waters and then recover and renew their depredations. Even when buried under one-fourth to one-half inch of dirt they recover and work their way out.

#### Temperature.

Frequent freezing and thawing destroys eggs that are in saturated soil. This may occur in any kind of soil. Capsules brought to the surface when the ground is stirred are broken up by freezing and the eggs destroyed by freezing and drying.

Eggs in sound, undisturbed capsules are not thus injured except in unusually wet winters.

The young of these species are killed by freezing weather, and cold weather checks their growth. The warm weather of Kansas growing seasons is very favorable for them. Very hot weather during the egg-laying period destroys the vitality of the eggs that are in unshaded ground. A temperature of about 120° F. is probably fatal to the eggs, while dry unshaded ground often reaches a temperature of 150° during the hot days of August. This effect of heat on grasshopper eggs was observed by the author during the fall of 1913, when many unbroken capsules were found to contain discolored and decaying eggs.

## **PREDACEOUS AND PARASITIC ENEMIES.**

### **Destroyers of the Eggs.**

Large numbers of grasshopper eggs are destroyed by the larvae of blister beetles and of bee flies. The larva, as found in the grasshopper egg capsules, bear a superficial resemblance to each other, both being white and grublike. They can be distinguished by means of the brown head and the three pairs of fleshy legs of the blister-beetle larvæ. The bee-fly larvæ are legless and have a small black point on the head. (Fig. 4.) In ground where grasshoppers deposit eggs year after year, from 50 to 75 per cent of the capsules contain bee-fly larvæ. A much smaller number of eggs are destroyed by blister-beetle larvae, but they rank next to the bee-fly larva as egg destroyers. (Fig. 5.) Of 1022 capsules examined during the winter of 1914-'15, 48.8 per cent contained bee-fly or blister-beetle larvae. The adult blister beetles are black, gray or brown insects that often eat the foliage of potatoes and beets, doing a great deal of injury thereby. (Fig. 6.) The adult bee flies are beelike flies that late in the fall are often seen along the edges of fields and in waste places. They dart about almost too rapidly to be followed by the eye, and often pause before flowers to sip nectar.

Mice, ground squirrels, moles and skunks dig up grasshopper eggs and eat them. Hogs also root them out for food.

A small wasplike parasite about one-eighth to three-sixteenths of an inch long lays its eggs in the eggs of the grass-

hopper. In order to accomplish this the female clings to the body of the female grasshopper until the latter lays her eggs. As the grasshopper digs the hole for her eggs the female parasite crowds into it along her abdomen, and thrusts one of her own eggs into each grasshopper egg.

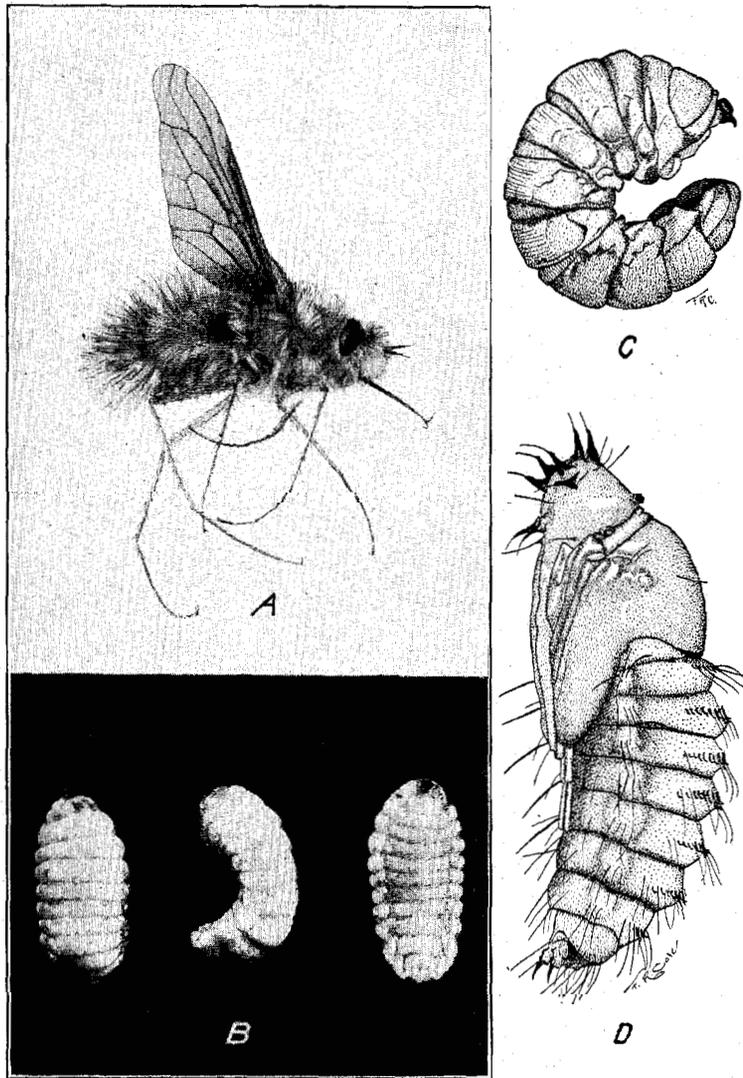


FIG. 4. The bee-fly. A, adult; B, dorsal, lateral and ventral views of the larva; C, larva; D, pupa; all greatly enlarged. (Furnished by U. S. Dept. Agr.)

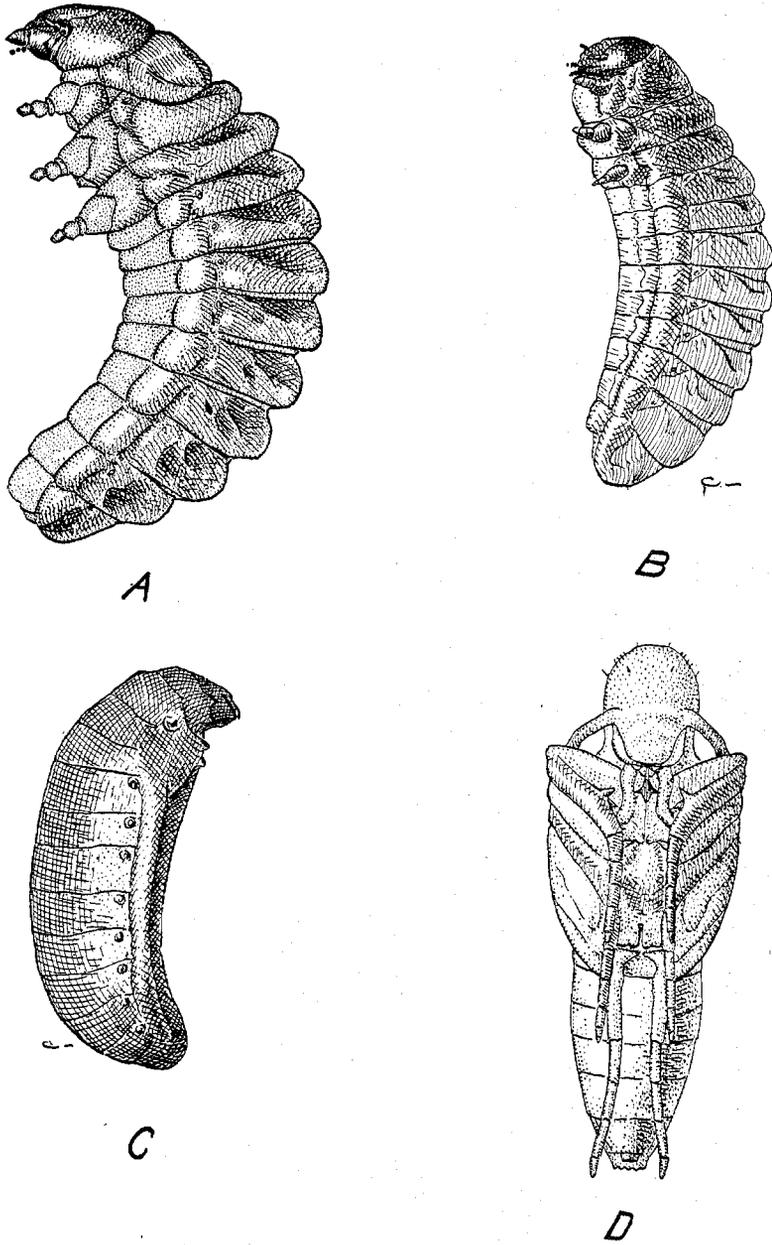


FIG. 5. Larval and pupal stages of the blister beetle. A, scarabaeoid larva (egg-eating stage); B, third stage of larva (active spring stage); C, coarctate larva (winter stage); D, pupa; all greatly enlarged. (Furnished by U. S. Dept. Agr.)

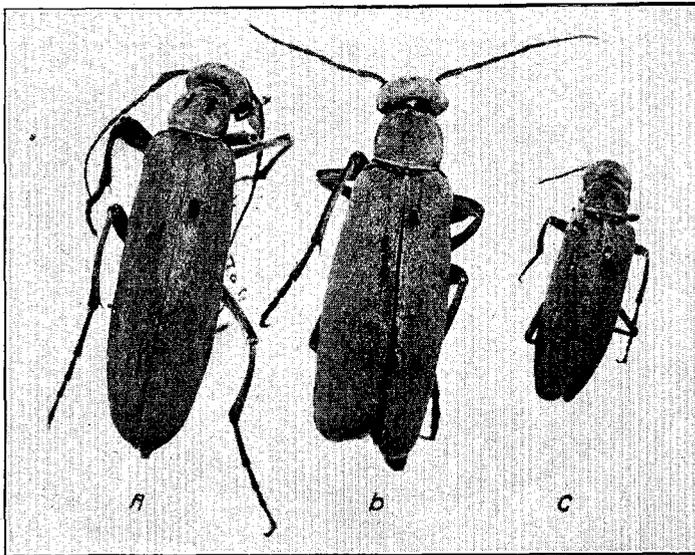


FIG. 6. Species of blister beetles that frequently do injury to potatoes and beets in western Kansas. a, The two-spotted blister beetle (*Macrobasis albida*); b, the immaculate blister beetle (*Macrobasis immaculate*); c, the spotted blister beetle (*Epicauta maculata*); all enlarged. (Original.)

### Enemies of the Young and Adults.

Wasps paralyze large numbers of grasshoppers and store them as food for their young. Several dozen, in a helpless condition, have been dug from a single wasp burrow. Other insects also prey upon them. The large lubber grasshopper (*Brachystola sp.*) has been observed to catch adults of the Carolina grasshopper. Toads, lizards, snakes and skunks catch large numbers. Cats and ground squirrels have been seen to catch and eat some of the larger kinds. Nearly all birds feed on grasshoppers, destroying large numbers. Sometimes chickens, turkeys and guinea fowl are raised to catch them.

The most important parasitic enemies of the large nymphs and adult grasshoppers are several species of flies. These flies are a little larger than the common house fly. (Fig 7.) They deposit maggots or eggs that hatch soon on the bodies or wings of grasshoppers. The maggots bore through the skin of the host and feed inside its body until full grown, when they tear their way out, killing the grasshopper. In the fall of years of severe grasshopper outbreaks these flies become very

numerous, and the maggots may often be dissected from the bodies of grasshoppers that are hardly able to jump or fly.

The chinch-bug fungus, which is known to science as *Sporotrichum globuliferum*, often kills large numbers of grasshoppers. Its victims climb to the tops of the tallest weeds and die, sometimes several in a cluster, holding with a grip that lasts until the bodies are weathered to pieces. The differential and the two-lined grasshoppers were thus destroyed at different places in the state during the fall of 1911, and a large number of the Bruner grasshoppers died from this cause in the western part of the state during the springs of 1913 and 1914.

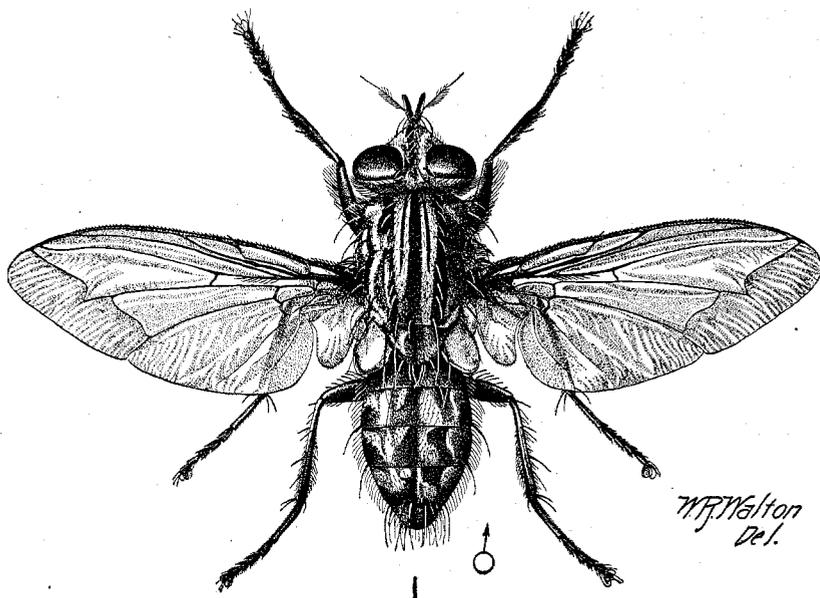


FIG. 7. A sarcophagid parasitic fly (*Sarcophaga kellyi*), the parent of one species of a maggot found within the body of grasshoppers. (After Kelly, U. S. Dept. Agr.)

## DESCRIPTION.

### Adults.

The differential grasshopper (*Melanoplus differentialis* Thos.) and the two-lined grasshopper (*M. bivittatus* Say) are similar in size and color. The Males are about one and one-fourth inches long, with wings that extend about one-fourth inch behind the body. The females are about one-fourth of an inch longer, and their wings reach only to the tip of the

body. The differential has a yellow body with black markings on the sides of the neck and the sides of the abdomen. (Fig. 8.) The outside of each hind thigh bears a row of black V's that open backward, with a row of black dots just below. The wings are olive green and the shanks yellow. The two-lined grasshopper has a brownish-yellow body, with a yellow

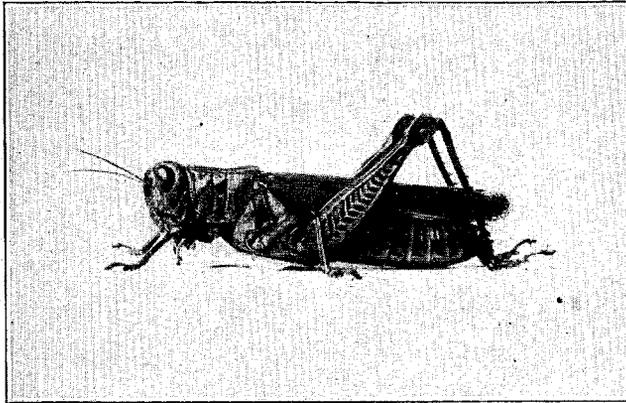


FIG. 8. The differential grasshopper (*Melanoplus differentialis*).  
(After Dean.)

stripe extending from each eye back across the neck onto the wings. (Fig. 9.) A black stripe runs lengthwise on the outside of each hind thigh. The shanks are usually bluish green.

The lesser migratory grasshopper (*M. atlanis* Riley) is the smallest of the species doing injury in Kansas. It is about one inch in length, with the wings projecting a little beyond the

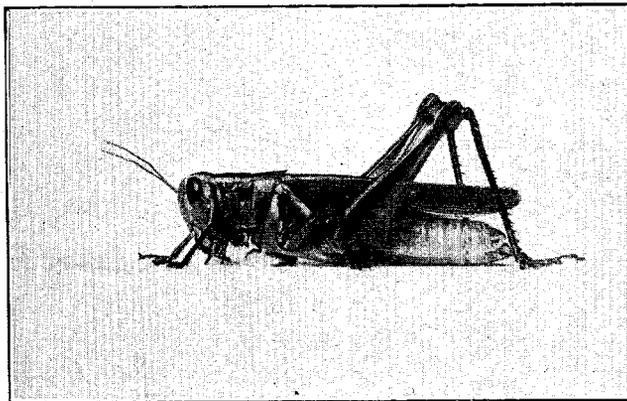


FIG. 9. The two-lined grasshopper (*Melanoplus bivittatus*).  
(After Dean.)

end of the body. (Fig. 10.) Its slender body varies in color from yellow to dark brown. The front wings bear longitudinal wedge-shaped areas in which are a number of rectangular black spots. This species is more generally distributed throughout the state than any other included in these investigations.

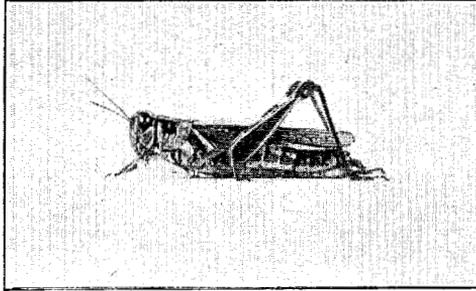


FIG. 10. The lesser migratory grasshopper (*Melanoplus atlantis*). (After Dean.)

The Bruner grasshopper (*Æopolus bruneri* Caudell) is about the same length as the lesser migratory, but has a heavier body. It is greenish yellow in color, with three bluish green stripes extending from the head back across the neck, one on top and one on each side. (Fig. 11.) The wings are olive green, finely netted with yellow cross veins. A wedge-shaped area runs lengthwise through the center, that bears light and dark patches. Three bluish-green zigzag stripes extend across the upper surface and down on each side of the hind thighs.

The Carolina grasshopper (*Dissostertia Carolina* Linn.) is a familiar sight along country roads and in pastures and fields, where it takes wing when disturbed. It darts rapidly about, often poising in the air with abdomen inclined downward, making a peculiar rustling sound by fluttering its wings. (Fig. 12.) Large numbers often collect at night around street lights and circle about until exhausted.

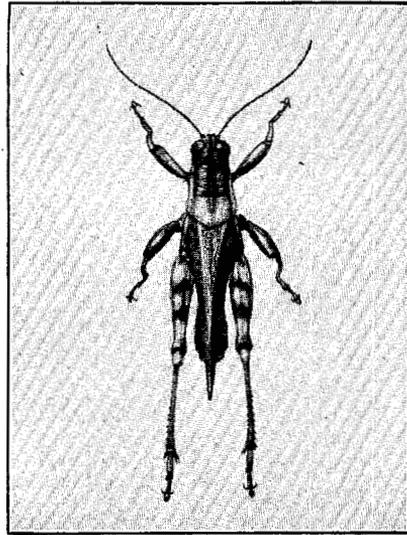


FIG. 11. The Bruner grasshopper (*Æopolus bruneri*). (From Farmers' Bulletin 691, U. S. Dept. Agr.)

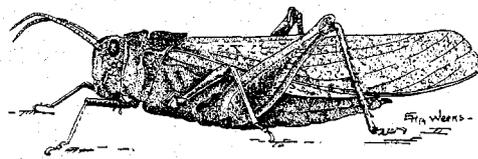


FIG. 12. The Carolina grasshopper (*Dissosteira Carolina*). (Original.)

### Eggs.

The eggs of these grasshoppers are much alike, being distinguishable only by persons who have studied them carefully. They are brownish yellow, but are often stained by the soil in which they are deposited. In size and shape they resemble navy-bean embryos after they have been separated from the beans by long cooking.

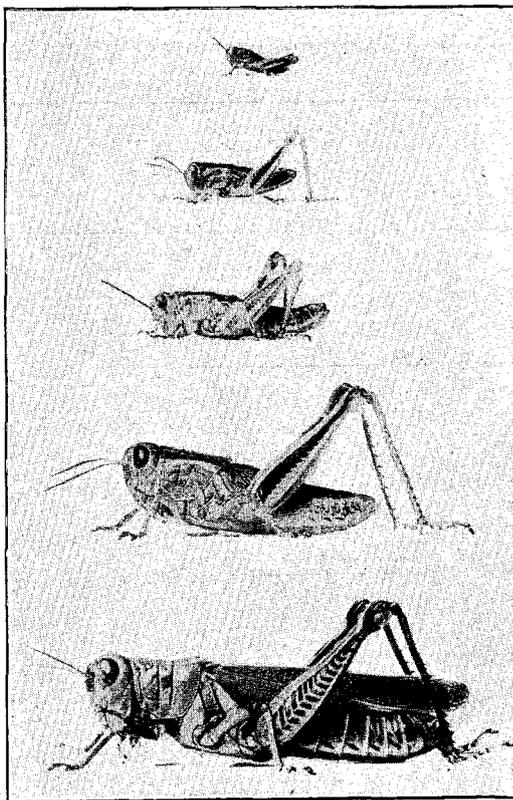


FIG. 13. Different stages of the differential grasshopper. (After Dean.)

### Nymphs.

The nymphs are from one-eighth to three-sixteenths of an inch long when hatched, and are easily recognized from their shape and their jumping habits. (Fig. 13.)

### LIFE HISTORY AND HABITS.

During the summer the adults of both sexes gather along roadsides, fence rows, ditch banks, in weedy spots of alfalfa fields and pastures, and in weedy abandoned fields. (Fig. 14.) The tall weeds and grass usually found in such places furnish

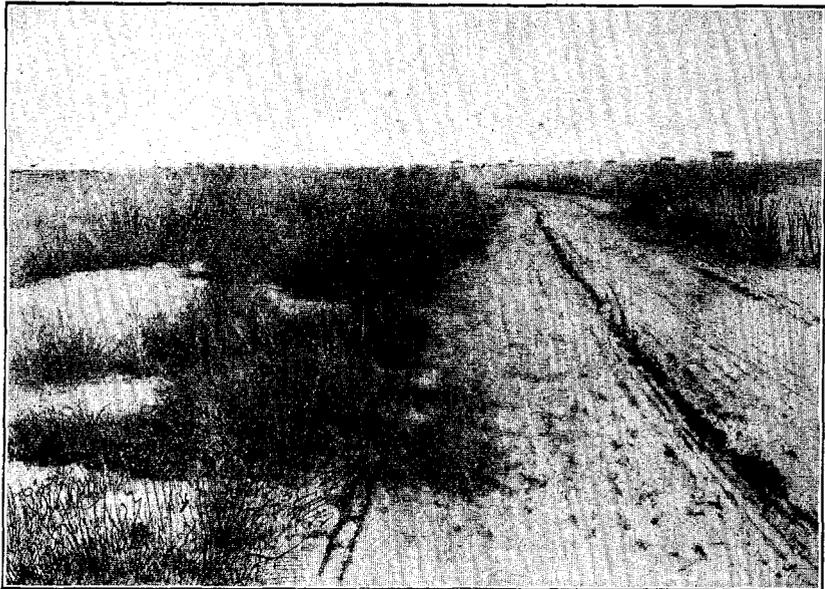


FIG. 14. A neglected roadside. Russian thistles, sage brush and other weeds, interspersed with buffalo sod, form an ideal breeding ground for grasshoppers. (From Farmers' Bulletin 691, U. S. Dept. Agr.)

a roosting place at night and shelter during cool or stormy weather. In such places the females deposit their eggs during August, September and October.

### Egg-laying.

The process of egg-laying is the same for all species on which observations have been made. The female works her abdomen downward and backward into the soil as far as it will reach. (Fig. 15.) The eggs are then deposited in the



FIG. 15. Differential grasshopper laying eggs; enlarged. (From Farmers' Bulletin 691, U. S. Dept. Agr.)

hole thus formed, with a quantity of white, frothy liquid which fills the spaces between them and wets the walls of the hole. As the hole is filled the abdomen is slowly withdrawn. As soon as she is through laying the female fills the mouth of the hole with more of the white, frothy liquid and covers the place with dirt. The liquid hardens as it dries, cementing the eggs and surrounding soil into a curved cylindrical capsule. (Figs. 16 and 17.) The egg capsules of the larger grasshoppers contain from 75 to 150 eggs, being about as thick as an ordinary lead pencil and from three-fourths of an inch to one and one-fourth inches long. The egg capsules of the smaller species are about half as thick and half as long and contain only from 20 to 35 eggs.

### Hatching.

The eggs begin hatching about the time of the last spring frosts, and the soft, white young push their way up to the surface, where they writhe helplessly for several minutes. They darken rapidly in color, and in half a day can hardly be seen when resting on the ground or on dead vegetation.

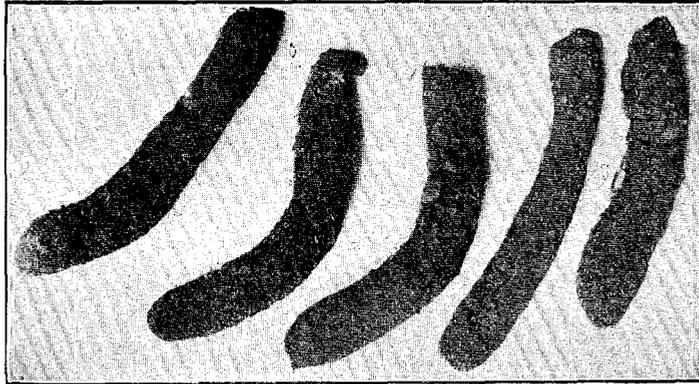


FIG. 16. Egg capsules of the differential grasshopper; enlarged 1½ times.  
(From Farmers' Bulletin 691, U. S. Dept. Agr.)

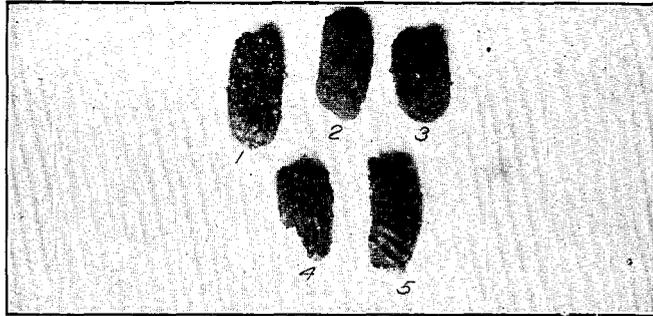


FIG. 17. Egg capsules of the Bruner grasshopper. 1, Dorsal view; 2, lateral view; 3, ventral view; 4, dorsal view of eggs in capsules; 5, lateral view of eggs in capsules; enlarged 1½ times.  
(From Farmers' Bulletin 691, U. S. Dept. Agr.)

### Growth and Habits.

Under favorable weather conditions the young grow rapidly, feeding on any near-by vegetation. They soon outgrow their skins, which finally burst, thereby uncovering the soft, elastic skins which have developed underneath. The old skins are left hanging to vegetation or posts, or lying on the ground, where they are often mistaken for dead grasshoppers. This shedding of the skin by the young grasshopper is known as molting, and occurs five times before they are grown. After each molt the skin is elastic, and for some time allows a rapid increase in the size of the insect; but it gradually hardens

until further growth causes it to burst again. The wings, which in the earlier stages of growth may be seen as small pads at the sides of the thickest part of the body, become serviceable as soon as they stiffen after the last molt.

Native grasshoppers, if hatched among green vegetation, travel very little. If food is scarce they go in search of it. However, the nymphs of all species are exhausted if compelled to take fifteen or twenty jumps in quick succession. Of the adults, only those of the lesser migratory and the Carolina grasshoppers possess greater traveling ability than this. But the former never migrates except in search of food or to escape unfavorable conditions, and the latter has not been present in sufficient numbers to do noticeable injury.

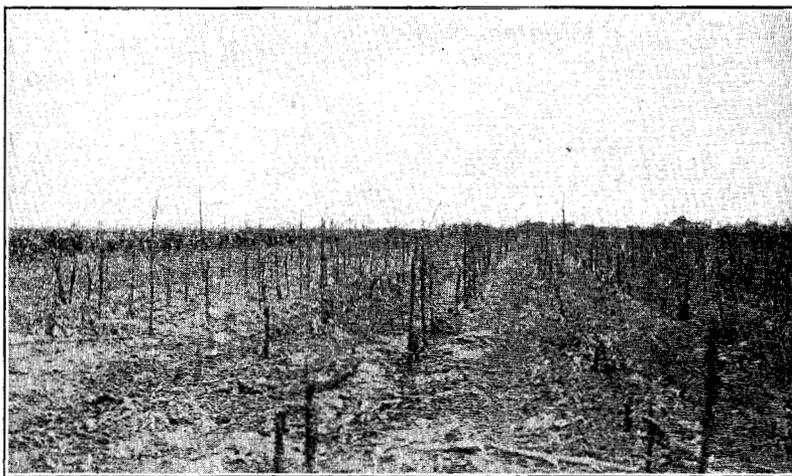


FIG. 18. Corn ruined by grasshoppers. (After Dean.)

During calm weather the grasshoppers spread slowly in all directions from their hatching place, wherever food is obtainable. A strong wind carries them when they jump, thus slowly drifting them over land to windward. Much of the period of daylight is spent in climbing over vegetation. Darkness finds most of them roosting in vegetation at some distance from the ground, and they are still in this position at day-break. As it grows warm they climb to the ground, but return and begin feeding when they become hungry. Feeding is more or less continuous, but the greater part occurs during the moderately heated portions of the day.

### Food Plants.

The injurious grasshoppers feed on nearly all weeds, on the foliage, fruit and bark of trees, on most field crops except the sorghums, and on most garden crops. (Figs. 18 and 19.) The

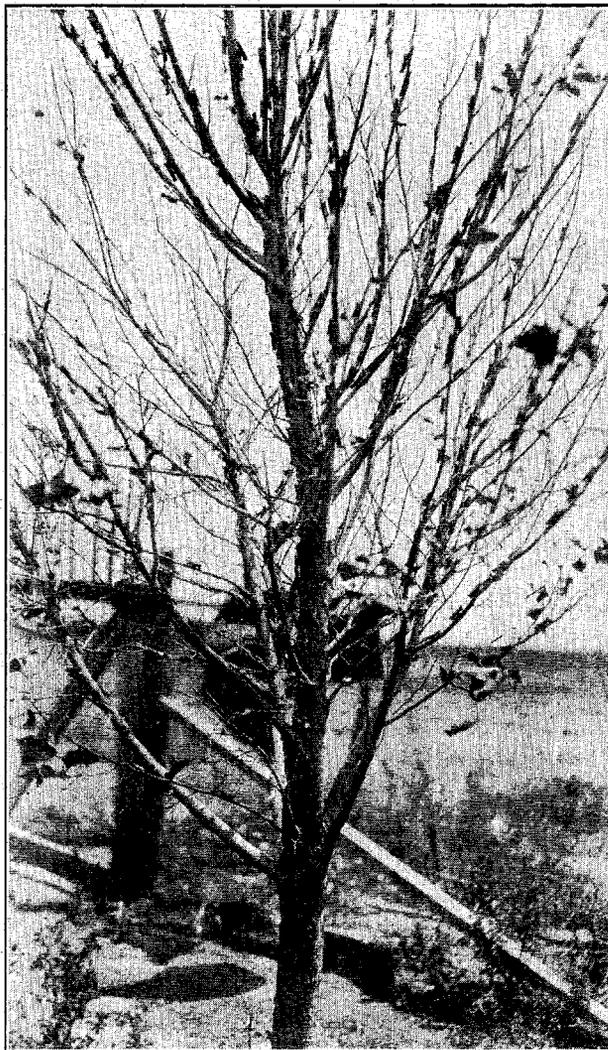


FIG. 19. Carolina poplar defoliated by grasshoppers. (After Dean)

sparse native grasses are not eaten when other food can be secured. In times of food scarcity any green vegetation, as well as dead vegetation and the bodies of dead insects and other animals, will be eaten. At such times their sick and weakened comrades are also overpowered and eaten.