HESSIAN FLY CONTROL
IN IOWA

male

female

egg laying

egg

pupa

larva

flaxseed
RECOMMENDATIONS

The Hessian fly can only be controlled by farm practices. After the fly has become established in wheat fields, no measures can be taken to control it. Injury can be prevented in but one way, namely, by seeding on or after the fly-free-date and thus keeping the fall brood out.

If losses are to be prevented, community cooperation in late seeding is essential, because one early seeded field will breed enough flies in the fall to infest all the fields in the community the following spring.

The recommendations listed below are effective and should be followed whenever possible.

1. Practice crop rotation whenever practical.
2. Plow under old stubble as soon as possible after harvest unless wheat is used as a nurse crop for clover or timothy.
3. Destroy volunteer wheat in cultivated fields by discing and harrowing on hot, sunny days.
4. Prepare a good seed bed. This conserves moisture and helps the wheat to get a good quick start.
5. Secure the cooperation of your neighbors so that no wheat is drilled before the fly-free-date. Get in touch with your county agent for information concerning the exact fly-free-date. Remember that the Hessian fly readily flies from one field to another and that a field seeded too early will be a center and a source of infestation for the entire neighborhood the following spring.

The front cover illustrates the life cycle of the Hessian Fly
Hessian Fly Control in Iowa

By C. J. Drake, F. A. Fenton and F. D. Butcher

The Hessian fly*, the most important insect pest affecting the wheat crop in Iowa, was imported from Europe probably either just before or during the period of the Revolutionary War. Its depredations were first observed on Long Island, New York, in 1779, in the vicinity of Lord Howe's old encampment site of three years before. As the Hessian mercenaries, who constituted a part of the foregoing army, were much despised in America and as it was generally supposed that the pest had been brought into this country in straw used for the bedding of these soldiers, the common and obnoxious name, "Hessian fly", was bestowed upon this insect. The fly spread rapidly westward and it is now established throughout the wheat growing belt of the United States. It would be difficult to estimate the total damage done by this pest since its importation into America, but tax amounting to at least $100,000,000 in a single year has been charged against it.

According to F. M. Webster, the first occurrence of the Hessian fly in Iowa was in 1860. Osborn, 1896, reports finding the Hessian fly in samples of wheat sent to the Iowa Agricultural Experiment station. Curiously enough, Osborn reports its appearance in the spring wheat belt of Iowa. From then up to the present, serious outbreaks have occurred at various intervals, the last being recorded by R. L. Webster in 1914. Last year, 1922, the Hessian fly destroyed over $1,500,000 worth of Iowa's winter wheat.

FOOD PLANTS

The Hessian fly is injurious to wheat and occasionally to a lesser extent to rye and barley. It also lives on western rye grass, as well as a few other grasses belonging to the same genus. Wheat is its preferred host plant. It will not breed up in any considerable numbers or even continue to breed on the other plants mentioned. Injury is caused only by the feeding of the maggot, (the larval stage).

HOW TO DETECT HESSIAN FLY INJURY

During the latter part of October and November wheat fields heavily infested with the Hessian fly can be detected easily at some distance, the normal rich green, lawn-like appearance being replaced by a sickly yellowish-green tint. At first, frequently, only portions of a field show these areas, or perhaps one end of the field may be more severely injured than the rest. In fact, very rarely will the percentage of damage be uniform throughout the entire field, due to difference in time of drilling, proximity to centers of infestation, or to the habits of the insects.

Earlier in the fall, individual wheat plants infested with Hessian fly larvae show the first signs of injury about six days after the eggs have hatched. The infested plants are a shade darker green in color than the healthy ones and the leaves tend to grow more stiff and upright, in contrast to the delicate drooping effect of the normal blades. Later the dark green color of the infested leaves is replaced by a yellowish-green tint and finally they wither and die.

When the leaves are stripped back, exposing the stem just above the point where the leaf originates, the chestnut brown flax-seeds or greenish-white larvae are disclosed, partially embedded in the plant tissues. The maggots or flax-seeds are generally located at or a little below the surface of the ground.

*Phytophaga destructor Say; family Cecidomyiidae; order Diptera.
Usually the infested plant has a tendency to send up suckers or tillers from below the point of injury. In severe cases, however, these are weak and often fail to break thru the surface of the soil. In light attacks, or where parasites are numerous and kill many larvae before they are mature, the secondary tillers often grow vigorously and form a new stand of plants. These sometimes pass thru the winter successfully and may form the basis of a fair crop. Frequently, many plants heavily infested with Hessian fly are killed outright during the fall, while others are so weakened that they winter-kill easily.

In the spring heavily infested fields present a spotted appearance with bare areas here and there. The occurrence of the fly in the fields at this time is confirmed by pulling up the dead and partly decayed plants which may be found in every row, and examining for the flaxseeds. Later, usually in April and May, the spring brood flies appear and lay eggs on the newer and more tender leaves of the growing plants. For this brood the larvae and flax-seeds are frequently located further up on the stem, usually at the first node above the ground.

The spring brood of flies not only further injure wheat that has been damaged the previous fall, but they also fly to and damage other fields in the neighborhood which were planted after the fly-free-date. Too late to plant corn or some other crop, the farmer frequently sees his supposedly recovering field “wink out” here and there until nothing worth while is left. Or again the plants may head out, but the heads do not fill properly. As they increase in size, and mature, the extra weight of the grain makes the weakened plant top heavy and it breaks over. This breaking occurs near the point of infestation, usually at the first or second node. Needless to say, this fallen wheat is difficult to harvest, altho if the weather is favorable, a part of it may be saved. Infested wheat very often lodges during a heavy driving rain and under such conditions, the heads are beaten into the ground and all chance of even saving a partial crop may be lost.

In stubble fields the presence of the flies is difficult to detect even in heavy infestations. The larger bunches of stubble from uninfested plants are easily found, while the infested, partly disintegrated straws are readily passed over.

The effect of Hessian fly infestation on the yield of wheat is the result of first, a thin and irregular stand due to killing of badly infested plants; second, partially filled heads and light grain largely due to attacks by the spring brood; third, inability to harvest much of the fallen wheat especially after driving rains just previous to cutting; and fourth, in case of a very heavy and severe infestation the entire crop may be lost.

**THE STORY OF THE FLY FROM BIRTH TO DEATH**

The parent fly is a small gnat somewhat resembling a mosquito. Its two wings are covered with minute hairs, giving them a distinctly dusky appearance. The body of the female, due to the presence of the reddish-brown eggs in the abdomen, is of a reddish cast. They are feeble fliers, but are carried by air currents and moderate winds for comparatively long distances.

There are two main broods of the Hessian fly during the year. The mature insects are found, and frequently in immense numbers, in wheat fields during the last few days of August and in September and then again during April and May. At these periods the females are very busy laying eggs. The egg is very minute, only about one-fiftieth of an inch long, slender, almost cylindrical and with both ends bluntly round. Its surface is glossy and its color a shade of vermillion red, which deepens with age. They are generally placed in rows of
from two to a dozen, in the grooves of the upper surface of the leaves. Caged females at our observation stations have been observed to lay over 300 eggs within 24 hours after emergence. Most of the eggs are deposited shortly after the female emerges from the "flax-seed" stage. After an incubation period of from 4 to 14 days, depending upon the weather conditions, the eggs hatch and the tiny reddish colored larvae or maggots move down the upper surface of the leaf, reaching the sheath beneath, where they finally come to rest at or near the node.

Here development takes place and the reddish color gives way to a greenish-white. In three or four weeks the maggot completes its growth, stops feeding, and then a curious and interesting change takes place. There is a slight shortening of the body, generally a brown tint overshadows the greenish-white color and later this intensifies to a brownish-black, the entire object resembling a "flax-seed", from which it derives its name. Within this covering (the flax-seed stage) the fall brood passes the winter and the spring brood the summer. Following this, depending again upon the time of year and weather conditions, the larvae moults and transforms into the pupal stage. As the time for emergence approaches the pupa works its way out thru one end of the flax-seed (puparium) and then continues its journey upwards until frequently it reaches the edge of the enclosing leaf sheath. Upon reaching a favorable location the adult fly breaks forth and becomes ready for flight in a remarkably short time.

**FLIES REPRODUCE AT AMAZING RATE**

According to McConnell (U. S. D. A. Bulletin No. 1008) the rate of reproduction of the Hessian fly is much higher than has been generally realized. At the time of deposition each female contains her normal allotment of eggs in a well developed condition. Within a few hours after emergence, under normal conditions, she deposits prac-
tically all of her eggs. The capacity for egg laying varies con siderably in different individuals, also in the two principal generations. The sexes of the fall generation are about equal in numbers, but in the spring about 60 percent of the flies are females.

Under conditions found last fall (1922) at the Onawa station, 603 Hessian flies emerged from one square yard of stubble or at the rate of 1,459,260 flies per acre. Assuming that one-half of these are females and that each female deposits an average of 285 eggs in the fall, there would be 415,889,100 eggs per acre. If these developed and passed thru the winter successfully and then 60 percent of the spring brood were females, this would give 249,533,460 females per acre. As each female at this time deposits an average of only 230 eggs, this would result in a total of 57,392,695,800* eggs per acre.

It is estimated that 1,000,000 plants per acre is a good wheat stand and hence in the above case there would be on an average of 57,392 eggs per plant. This does not represent the total number of flies or eggs, as there are a few flax-seeds (about 5-12 percent) of the fall generation that do not emerge until the following spring. From these figures it is evident that anything that helps cut down reproduction is of tremendous benefit. It will readily be seen from the above that a farmer's chance of securing a wheat crop by early sowing in a badly infested region is practically nothing.

HOW TO DETERMINE THE FLY-FREE-DATE

The principal means for controlling the Hessian fly are its parasites, unfavorable weather conditions and, the most important by far, not to sow wheat until the fly-free-date has been established. By delaying until the “fly-free-date” is meant sowing wheat so that it will not be above ground during the egg laying period of the fall brood of the Hessian fly. So effective is this method that practically complete control may be secured by means of it.

Formerly, definite “safe-dates” were computed for different states, these dates being based largely on longitude, latitude, altitude and an average of previous safe-sowing records. Sometimes by sowing at or after this arbitrary date, good results followed, but frequently failure to control the fly resulted. While the theory of late planting is good, the difficulty of setting a “fixed date” is evident when it is known that climatic conditions vary in a given locality from year to year. In order to determine the fly-free-date under natural conditions, three field observation stations were established in the badly infested regions of the state with an experienced entomologist in charge of each.

Observation Stations (1922) were located as follows: H. E. Evans farm, Onawa, Monona county; J. R. Brewbaker farm, Spring Hill, Warren county, and Bert McClintock farm, Essex, Page county. At each station a series of definite observations were made each day.

First, “concentration boxes” were set up in a heavily infested field of wheat stubble. Such a cage consisted of a tight, heavy, drygoods box with the bottom taken out and placed over about three bushels of carefully selected stubble, including roots and adhering soil, known to contain many flax-seeds. Two circular holes were sawed in the top of each box and into these lantern globes were inserted, the tops of which were covered with cheese cloth. As the flies are attracted

*Needless to say, this rate of reproduction never occurs in nature due to parasites, predacious enemies, and unfavorable climatic conditions. Moreover, an infestation is never uniform through an entire community, and in the case of very heavily infested plants, many of the maggots perish before reaching maturity.
Fig. 2. Seasonal cycle of the Hessian fly in Iowa.
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to light, immediately after emerging from the flax-seeds in the old stubble they flew upwards and collected in the globes. Each day the emerging flies were counted and removed from these globes. In order to approximate natural conditions, the stubble and dirt in the concentration boxes were moistened after each rain, the amount of water used depending upon the total rainfall. The appearance of the flies in these boxes gave in a relative way the daily rate of the emergence of the Hessian fly.

Second, a small wooden box, called “stubble box”, one yard square, was placed over the old stubble in the field near the concentration boxes. Two vials were inserted in each end of the box, daily records being taken of the number of flies emerging from a square yard of stubble. The stubble under the “stubble box” was treated in the same way as the “concentration box” after each rain. The stubble box gave the approximate density of infestation in the field.

Third, a “migration screen” was set up. This consisted of two strips of ordinary screen wire, 3 by 5 feet, covered with thinned “tree tanglefoot”, a sticky preparation retaining its sticky nature under outside conditions for several days. One of these screens was placed facing east and west, and the other, north and south. In this way no matter in which direction the wind currents were moving, a relatively constant number of migrating flies out in this stubble field were caught in the tanglefoot. Each day the flies were counted and removed from the migration screen. The migration screen and stubble box checked up the rate of appearance of the flies in the field.

Fourth, a small plot of wheat, called “trap crop”, was planted about a week or ten days before the observation station was actually started so that the wheat plants were up to a size suitable for oviposition when the flies began to issue from the old stubble. Exactly one hundred of these plants were labeled for daily egg counts. Each day the number of eggs laid on these marked plants were counted and removed.

Fifth, each day “flax-seed counts” were made from old stubble to determine the percent of flies that were yet to emerge. On account of weather conditions there was a great deal of daily variation in the number of flies emerging, and also in the number of eggs deposited, but by means of field flax-seed counts it was possible, regardless of fluctuations in the emergence of the Hessian fly due to climatic conditions, to determine the fly-free-date. Hence, the daily flax-seed count was the most important and reliable factor in ascertaining positively the fly-free-date. It determined exactly the relative percent of flies already issued, those which were still in the pupal stage and which would soon emerge, and also those which were still in the larval stage and would not appear until the following spring. By means of this count it was not only possible to forecast how heavy the last end of the fall emergence would be, but also to determine the rate of the approach of the fly-free-date, and, moreover, to avoid being caught by an abnormal, late fall wave of the fly. When the count showed very few pupae and only a small percent of larvae in contrast to a large number of empty flax-seeds, it was proof that the fly-free-date was at hand, and that the few flies yet to issue would appear, lay their eggs and perish before wheat drilled at this time would come up.

*A small percent of the summer larvae are hold-overs and do not pupate and emerge as flies until the following spring.
Fig. 3. Sketch showing plan of field observation station.
ORGANIZING AND COOPERATING TO CONTROL THE PEST

The data obtained at each observation station from the five foregoing experiments were mailed each evening to the central office at Ames. Here these records were summarized, tabulated and put into a circular letter and then immediately forwarded to the county agents cooperating, also to the men in charge of the field stations. In turn, the county agents published the records each day in the local papers, posted them on bulletin boards, and sent a form letter to the local farm bureaus. In this way all the farmers cooperating were kept in close touch with the daily Hessian fly situation. As the season advanced and the fly-free-date began to approach, the men in charge of the field stations wired their records to Ames. These records were then broadcasted by wireless and also mailed to the counties cooperating. In this way it was possible for the farmers to be prepared and
to begin seeding at the earliest possible moment, as soon as the fly-free-date was established.

In Monona county, September 29, a total of 4,089 flies issued from the cages in 24 hours and 5,615 eggs were laid in this period on the 100 marked wheat plants. Yet on this date flax-seed counts revealed the fact that all but 11 percent of the flies were out and that less than 1 percent were pupae. Thus, it was evident that there would be a marked decrease in the number of flies emerging within the next 24 hours, and likewise a decided decrease in the egg count, since most of the flies lay their full complement of eggs within 24 to 48 hours after emergence and perish. Therefore, in spite of the fact that the peak of the emergence was reached on this day, it was evident that most of the flies were out and that egg laying would not continue much longer. The season was already advanced and many farmers had 100 acres or more to drill.

In view of these facts, the following word was sent out to the men in charge of the field stations and to the county agents cooperating: "Advise farmers with large acreage begin sowing at once; those having less, delay planting a day or two". The above telegram was sent to Monona county district, September 30; to Warren county district, October 1; and to Page county district, October 3.

Seven days after the fly-free-date had been announced the fall brood had disappeared and wheat coming up at this time was found to be free from Hessian fly eggs.

In contrast, wheat fields which had been planted before the safe date was announced, were without exception moderately to heavily infested. As the tail end of the brood was especially heavy, several fields drilled only two or three days before the fly-free-date were found to be slightly to heavily infested. However this spring (1923) some fields sown on or after the fly-free-date became infested by flies migrating from fields in the neighborhood that were drilled too early. Thus, it is evident that only by complete community cooperation of all wheat growers in late seeding that effective control of the Hessian fly may be secured. In this way only can Hessian fly damage be forestalled.