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THE SO-CALLED "GREEN BUG" AND OTHER GRAIN APHIDS IN MINNESOTA IN 1907.

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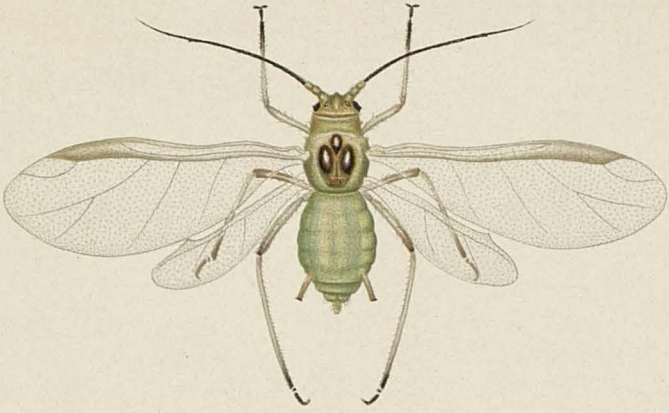

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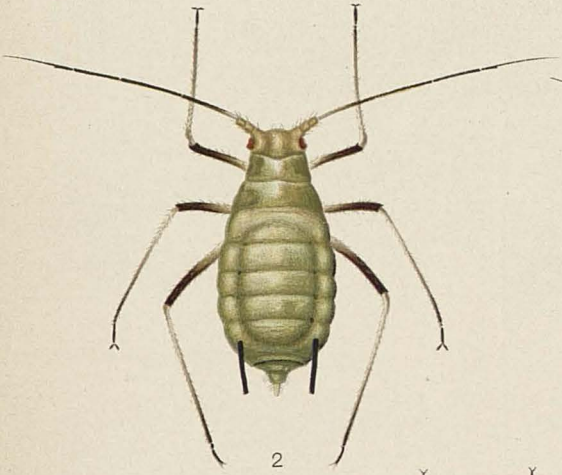

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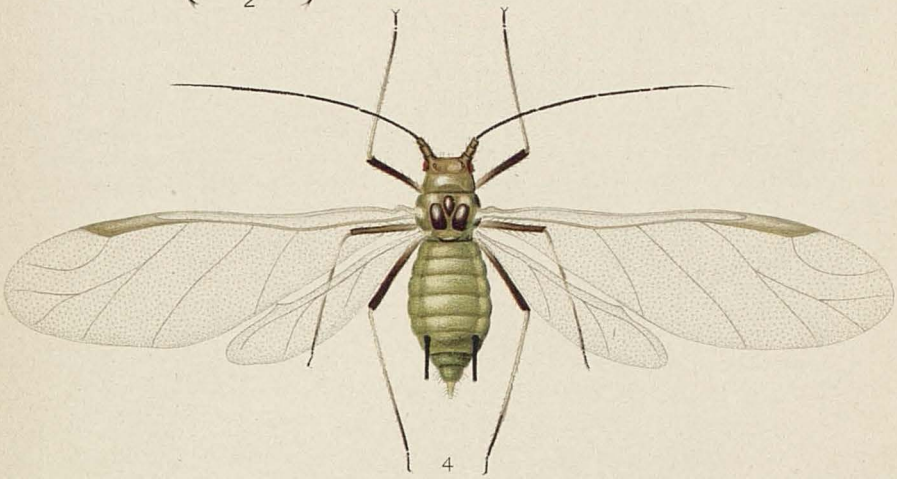

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I. L. WOOD

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THE SOUTHERN GRAIN APHIS, OR SO-CALLED "GREEN BUG," 1, 3, AND A NATIVE FORM, MACROSIPHUM GRANARIA, 2, 4, COMMON IN MINNESOTA.

THE SO-CALLED "GREEN BUG" AND OTHER GRAIN APHIDS IN MINNESOTA IN 1907.

F. L. WASHBURN.

GENERAL REVIEW OF CONDITIONS IN THIS STATE; FOOD PLANTS, FIELD WORK, ETC:

The unusually mild winter and cool spring of 1907 in the southern states, enabling the "green bug" to multiply without interruption from its parasite, were the causes of the outbreak last season in the South. Minnesota has long cold winters and warm summers. The first factor renders it impossible for this pest to multiply in the winter or early spring as it does in parts of the South. The second factor is favorable for the rapid increase of its principal parasite, which is found in this state, and which even in the South in ordinary years, keeps the pest in check. Therefore, in all probability, the Northwest will never have cause to fear an outbreak of the "green bug," or any other louse affecting grain.

Not since "grasshopper times" has an insect caused so much excitement in this state as did the "green bug" last summer. The conditions were remarkable in that, as in our recent financial panic, the scare was largely artificial. The insect flourished in the wheat pit, and afforded a fine club in the hands of those who would bull the price of grain. So-called "crop experts" sent into the field by railroads and other parties, apparently vied with each other in sending in alarming reports. To our certain knowledge, at least one party (and there were doubtless many others) was sent from Chicago through Minnesota

and the Dakotas, and was paid to send in lurid accounts of the work of the green bug. Early in spring, at the time the seriousness of the situation in Kansas, Texas, and Oklahoma was becoming apparent, it hardly seemed possible that the pest would reach Minnesota that season; and even if it did, the entomologist claimed, in all probability it would do no actual harm to the wheat crop. It *did reach here, but, as was prophesied, it did not affect the wheat crop.* It did, however, have a disturbing affect upon the market, partly because many of the observers, including many grain buyers and sellers were actually deceived by the close resemblance between a native, northern grain aphis, *Macrosiphum granaria,* and the southern or spring grain aphis, *Toxoptera graminum,* the so-called green bug. We use the terms "native" and "northern," in this connection merely to contrast the two forms. As a matter of fact *M. granaria* was undoubtedly originally a European or English form. Some writers here refer to it as "the English Grain Louse." This similarity is well shown in the colored plate at the beginning of this bulletin. There were others, as intimated at the beginning of this article, to whom, for trade reasons, everything on the grain was a "green bug."

Our farmers and citizens generally, seeing lice on the heads of wheat, and calling all insects by the popular term "bugs," and noting further that they were green, at once cried "Green Bugs!" At that time, owing to tense conditions in this direction, every bug on wheat which was green was not *a* green bug, but *the* green bug, and immediately startling headlines appeared in our daily and county papers, causing anxious hours for wheat raisers, and filling the heart of many a speculator with unspeakable joy.

Two trained assistants, R. L. Webster, and George G. Ainslie, were detailed by the writer for field and insectary work upon this and allied insects. Later observations were carried on by Mr. R. A. Vickery, assistant in charge of the insectary.

We were repeatedly told in the early part of the game that we had "green bugs present on the Experiment Station farm, and did not know it!" We *did* have a form of grain aphid, *M. granaria,* but not until July 5th did we find at St. Anthony Park the genuine "green bug," *Toxoptera graminum,* Rond., at which time winged forms were found on corn by Ainslie. On July 6th Webster found both winged and wingless forms producing young at Hastings. Meanwhile, from the very beginning of the cry of "Wolf! Wolf!" or rather "Green bug! Green bug!" we had kept quite constantly one, and frequently two experts in the field patrolling our southern border. These men were entomologists, and could, by using their magnifying glasses, at once distinguish the southern visitor from our more common northern form. Reports from them either by letter or wire were received almost daily, and, up to the

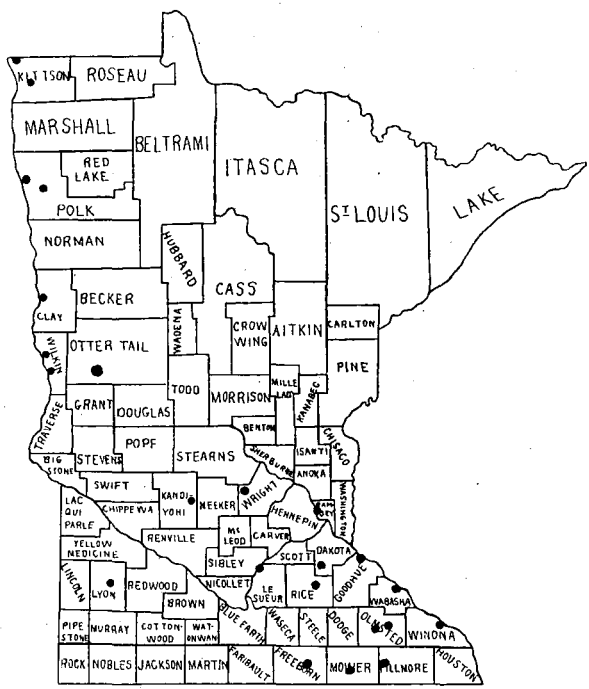

Fig. 1 Map of Minnesota. The dots show where we found the green bug, *Toxoptera graminum,* in 1907.

date mentioned above, were all of the same tenor, "No green bug here," "Plenty of Macrosiphum, no Toxoptera," etc. After the date above given, however, during the remainder of the summer, and into the autumn we found the southern form at every place visited, and doubtless it was present in small numbers almost everywhere in the grain-growing districts of the state. It was found to be present from the southern to the northern border. Webster found specimens of Toxoptera at Noyes Station, within a few hundred feet of the Canada line, opposite Emerson, Manitoba. This species was also found at Wabasha, Winona, Dover, Rochester, Spring Valley, Austin, Albert Lea, Fergus Falls, Breckenridge, Wolverton, Moorhead, Crookston, East Grand Forks and Hallock, and also at Robbinsdale, Cokato, Atwater, Marshall, LeSueur, Northfield, and Farmington. It was found commonly upon corn and oats, less frequently upon wheat. It was found on Blue grass at St. Anthony Park, July 5th, and on Timothy, July 6th; on millet at Moorhead, July 31st, and on barley at St. Anthony Park, September 1st.

The same parasite that attacked *Macrosiphum granaria* (*Lysiphlebus tritici*) also attacked Toxoptera. Parasitized specimens of Toxoptera were found at Moorhead and other places, which, no doubt, owed their death to this species. Many specimens of this parasite were reared in the insectary during the season.

Toxoptera when found on corn, was always on the under side of the lower leaves; on wheat, oats, and other grains and grasses, on the leaves, both on the upper and under surfaces. This insect was never found, according to reports of our field workers, on heads of any of its food plants, differing in this respect from *Macrosiphum granaria,* which attacks the heads as soon as they appear.

On September 1st at St. Anthony Park, Webster found numerous adults of Toxoptera inside the sheath of a barley plant. The last occurrence of Toxoptera in the field, according to notes, was on September 17th, when it was found on rye at St. Anthony Park. In this instance a

single apterous form was found on the inner surface of a rye blade. *No sexual forms were found outside at any time* though search for them was kept up late into the autumn. We had no difficulty, however, in getting these forms in the insectary, and securing eggs from them. These eggs have been placed out of doors to determine whether, or not they can survive our winters. Although Toxoptera was not found out doors in this state later than September 17th, it was probably because we did not have time to search for it thoroughly enough. After the ripening of small grain and maturing of corn, the green bug normally migrates to volunteer grain and grasses, and later, when the cold weather comes in October the eggs are laid on grasses or on winter grain, although young are probably produced viviparously up to the time of zero weather. These conclusions are based on the insectary experiments, which were carried on at outdoor temperatures.

A glance at the accompanying map will show where we found Toxoptera. However, in practically every instance it was found to be far out-numbered by the northern form, which we always have with us, and what little harm was being done to wheat was caused by the latter which we call the native form, and not by the "green bug."

It will be seen that the summer's campaign was peculiar in being directed not against the bug itself, but against the disquietude and anxiety caused the farming community and others largely by the unscrupulousness of parties who, for personal gain, sought to keep the agitation at fever heat. Doubtless the same scare, or practically a similar one, will be made use of the coming season, with the same selfish ends in view. It is to be hoped that our farmers will not be unnecessarily worried by the time-worn artifices of the speculator. However, in considering the conditions in Minnesota, we must not lose sight of the fact that Kansas, Texas and Oklahoma did suffer materially last season from this source, acres of wheat turning brown under the persistent attacks of the rapidly multiplying hordes of lice, and in the southern states apparently,

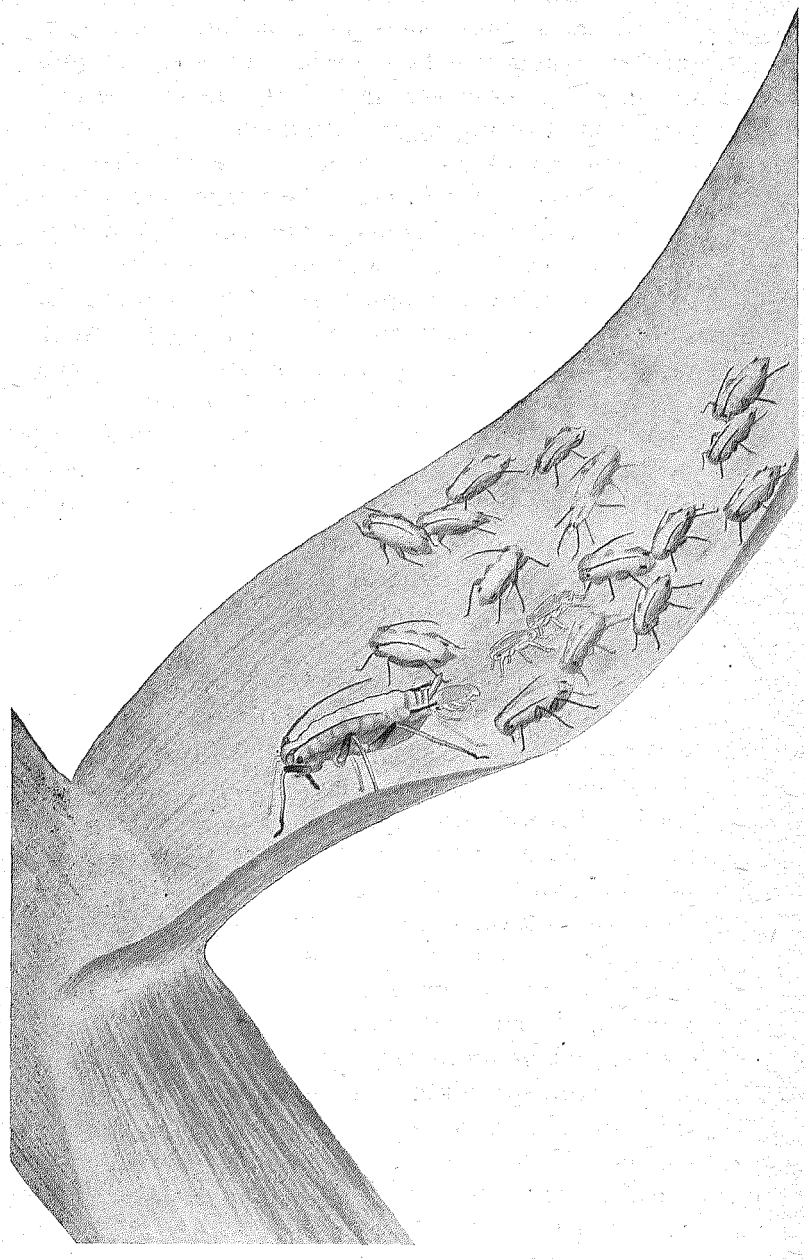

Fig. 2 A viviparous female of *Macrosiphum granaria*, with her newly born young, on leaf of barley. These young lice are all females, and each, when a few days old, will begin to produce more females as abundantly as in generation illustrated. Drawn from life. Original.

when climatic conditions are especially favorable, the advent of the "green bug" will be regarded with well-grounded anxiety. Like other aphids Toxoptera inserts its beak below the surface, and by sapping the vitality of the plant will either kill the plant outright, whole fields turning brown as a result of their work, or the plant will be dwarfed, either producing no heads or small heads without kernels. Orchard grass (*Dactylus glomeratus*) appears to be very attractive to these insects.

History of the Green Bug in the Southern States, Including the 1907 Outbreak; Europe Its Original Home.

Toxoptera graminum, Rond., was reported in Europe for the first time in 1852, in which year it was described in an Italian journal under the name of *Aphis graminum* by Dr. C. Rondani. It was reported then as feeding on oats, wheat, spelt, various grasses and corn. In 1863 it was redescribed by Passerini and placed in Koch's genus *Toxoptera.* In 1884 it was reported as infesting parts of Hungary, and referred to as one of the most destructive enemies of barley in that country. As far as known it first occurred in the United States in 1882. We have no absolute proof that this insect was brought to us from southern Europe beyond the fact as emphasized by Pergande (Bul. No. 38, Bureau of Entomology, U. S. Dept. Agric., 1902) that if it were indigenous we would have observed it upon grain from the earliest time grain was grown here, whereas, it was not observed here until 1882, and then in states bordering upon the Atlantic Ocean.

In 1884 it was found in limited numbers on wheat in Maryland. In 1885 F. M. Webster of the U. S. Entomological Bureau, at that time stationed at Oxford, Indiana, made some interesting insectary observations upon this louse, reporting that the winged females produced from one to four young a day, while the wingless females produced more rapidly. He states that an imago female in his insectary produced "thirty-seven offspring in eighteen

days, and at the end of this time some of the offspring were themselves grandmothers!"

In 1890 it was found in injurious numbers on wheat in Indiana and in certain sections of that state the oat crop was a failure through its ravages. In the same year they were found spreading abundantly through some of the southern states, Tennessee, North Carolina, Texas, Missouri, Kentucky, and also Illinois. In 1900-1901 Texas suffered severely, as did Missouri in a less degree.

The mild winter preceding the summer of 1907 in the South, followed by a late, cool spring, conditions favorable for the increase of the green bug (it is claimed that Toxoptera will breed freely in a temperature ranging from 100°F. to below freezing) and unfavorable for its chief parasite, gave the former a splendid start, and the parasite did not do effective work in consequence until too late. Practically the same weather conditions prevailed in 1890 and 1901, the dates of the preceding outbreaks. In 1907 east central Texas first reported green bugs in January on fall oats, and by March 27th they were present in destructive numbers. An agent of the Department of Agriculture found it in Arkansas in March on wheat, also in Oklahoma. March 30th the same worker found it in Kansas. Quoting from a department report as to conditions in Kansas: "By March 27th the green bugs developed winged adults in great numbers, and *these seemed to drift northward.*" The italics are the writer's. A later report from Kansas states that winged migrants were being produced there as late as January 31, 1908. The artificial introduction of parasites into infested fields by the government was without practical results, for wherever they were introduced countless numbers of parasites were found to be already there. Oklahoma lost in 1907 through the work of the "green bug" over $10,000,000. This is a very conservative estimate.

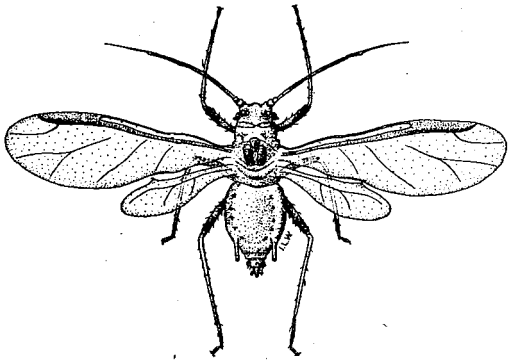

Fig. 3 Winged male "green bug." Original.

How Did the Green Bug Reach Minnesota? Its Life History.

The answer to this question involves a knowledge of the life history of plant lice in general, for they all follow

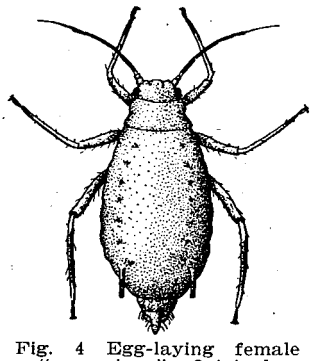

Fig. 4 Egg-laying female "green bug." Original.

Fig. 5. Eggs of "green bug" Original.

in a general way, as far as our knowledge goes, practically the same course. From the eggs in the spring hatch viviparous females, which, when they are a few days old, produce, parthenogenetically, living young (some species four or five a day) for several days before dying. These wingless young are all females (see Figs. 2 and 3 of colored plate), and each one reproduces more females in the same way, and at about the same rate. It will be readily seen that, eliminating unfavorable climatic conditions and predaceous and parasitic enemies, the descendants of one original female hatching in May would form an enormous horde of lice before September. The rapidity of increase on the part of an insect so tiny will account for the immense amount of damage done by them. Now, from time to time, instead of a wingless generation of females, we find produced *winged migrants* (Figs. 1 and 4, colored plate), and they also are viviparous females. These migrants offer the means for a wide dispersal of the pest. In the case of *Toxoptera* the withering or ripening of the grain brings out the winged migrants in rapidly increasing numbers. It was by means of these that the "green bug" reached Minnesota; not, it must be noted, by sustained flight to our state; that would be, we believe, out of the question, but more probably the winged forms borne north some distance by the prevailing southerly winds, settled on grains or grasses, started new wingless generations, which in turn produced more migrants, and these were likewise carried north, the process being repeated until we found this form (regarded as "southern") in varying numbers, not only in our fields, but even on our northern border. In the autumn true sexual forms, male and female (Figs. 3 and 4 in text) appear, and after mating eggs are laid by the female, which eggs are destined to give rise to the first females of the following spring. We have been unable to make them oviposit outside, or to find eggs which could be referred to that species, but in the insectary the sexual female (Fig. 4) laid freely on barley, placing her eggs on both dead and green leaves (see Fig. 5).

Other Grain Aphids Found Here; Field Work With the Same.

Field Work.—The most common grain louse, and the one generally taken for Toxoptera is *Macrosiphum granaria. This species is in general coloration a little darker green than Toxoptera, the honey tubes are in most of the stages black for their whole length, legs darker than in Toxoptera, and eyes inclined to reddish, while those of Toxoptera are black.* (See colored plate.) *In the winged migrant the discoidal vein is twice branched* (note front wings of Fig. 4, colored plate), *while in Toxoptera migrant* (Fig. 1, colored plate), *the same vein branches but once.*

On account of many people mistaking this for the southern form our two field workers, Webster and Ainslie, were detailed to make a special study of this species in the field, in connection with their observations on *Toxoptera.*

The species was first seen on May 20th at Albert Lea. At this date a single specimen was found in a field of oats east of Albert Lea by Webster. This specimen was adult and winged. On the following day winged forms and their young were found on barley at Albert Lea. From this time on until late in the fall the insect could be found either on grains or grasses. These first forms were all winged. No wingless forms at this time were found. The generation from the egg, or pseudogyna fundatrix form, is supposed always to be wingless. If this is the case with *Macrosiphum granaria,* it must have been at least the second generation, or perhaps even a later generation that was found May 20th.

On a trip made during the latter part of May and first of June, it was found at Albert Lea, Winnebago, Jackson, Worthington, Marshall and Willmar. None were found at Luverne or Pipestone at this time. In June the presence of *Macrosiphum granaria* became very noticeable in fields in the southern part of the state. At Albert Lea, June 14th, Webster found many individuals, although no appreciable damage to grain had been done at that time.

In response to a number of "green bug" reports from Winona, Dover and Rochester, an assistant was sent to that part of the state to investigate the actual conditions. This trip was made in July, a few days after the discovery of *Toxoptera graminum* in Minnesota. At Hastings, Wabasha and Winona *Macrosiphum granaria* was found very numerous, and causing considerable injury in the grain fields. At Dover and Rochester, however, this insect, *Macrosiphum* was extremely abundant, especially so upon oats. At Rochester a field of oats about four miles south of town was very badly infested with the grain louse. Yellow patches appeared generally over the field where the stand was thin and plants shorter than those surrounding. In these patches the aphids were most numerous, although the field was fairly alive with the grain lice. This was the first infested field seen during this trip. Spring Valley, Austin and Albert Lea were visited on the same trip. The grain louse was found in all of these localities, but not especially numerous in any of them.

SUMMARIZING.—*Macrosiphum granaria* was found practically all over the grain-growing portion of the state. The following places were visited, and the species found in each instance: Hastings, Wabasha, Winona, Dover, Rochester, Spring Valley, Austin, Albert Lea, Owatonna, LeSueur, St. Paul, Winnebago, Jackson, Worthington, Marshall, Willmar, Fergus Falls, Breckenridge, Moorhead, East Grand Forks, Crookston, Hallock and Noyes Station near the international boundary, opposite Emerson, Manitoba. Mr. Ainslie also found *Macrosiphum granaria* at Robbinsdale, Cokato and Atwater, and Dillon found it at Hinckley, Pine City and St. Cloud.

FOOD PLANTS.—*Macrosiphum granaria* was found generally on wheat, oats, barley, corn and rye. It was found on millet (*Panicum*) and timothy at Hastings, July 6th; on quack grass (*Agropyron repens*) at Rochester, July 11th; on speltz at Rochester, July 12th; on flax at East Grand Forks, August 1st, and on pigeon grass (*Ixophorus*), August 13th, at St. Anthony Park. It was also found on wild

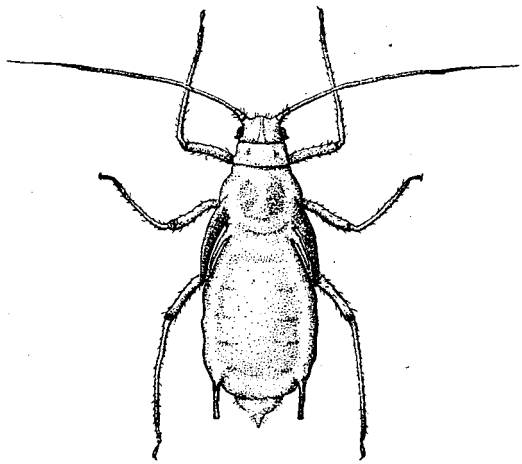

Fig. 6 Nymph of *Macrosiphum granaria*, enlarged about fourteen times. Original.

rye (*Elymus*) at Pine City, September 3rd, by Dillon, and upon *Bromus*, September 3rd, by Ainslie and Vickery at St. Anthony Park, and upon *Elymus canadensis* at St. Anthony Park, October 13th by Vickery, and on blue grass (*Poa pratensis*) by Vickery, November 7th, and upon pea. Mr. Vickery also found a viviparous female of this species producing young upon young pea, October 29th, at St. Anthony Park, and Mr. Ainslie found it upon June grass at St. Anthony Park, May 29th.

Heads of fife wheat were found to be less subject to attack by this species of aphis than heads of blue stem. On the young plants no difference was noticed in the varieties of wheat as far as susceptibility to attack was concerned. After the grain is cut or becomes ripe the lice are forced to other food plants. Pigeon grass appears to be the favorite food plant in Minnesota after harvest. This is very common in the stubble. Winter wheat and rye become infested in the fall.

When *Marcosiphum granaria* was first found in the spring it was only on the young grain plants. All the aphids at that time were found on the inner surface of the blade of the grain, none were found on the stalk of the plant itself, and few in the axils of the leaves. The aphids

continued to breed on the blades of the small grain until it began to head out, when they moved to the head. At Wabasha, on July 9th, an oat plant was found that had a single leaf blade *upon which were sixty-five grain aphids,* old and young. It was noticed that just before the plant was ready to head out the aphids were found very numerous in the axils of the leaves at the place where the head first appears. As soon as the head appears the aphids attack it.

In wheat, rye and barley the lice worked themselves down between the kernels of the head. Here they lie with the hear inward, their beaks inserted in the plant itself, taking nourishment from the head, and also producing their young. In wheat and rye heads the aphids could be easily seen in his position, but in barley heads they were less easily observed. This changing from the leaves to the heads was also true in the case of oats, where the grain lice can be easily seen upon the separate kernels.

Rye being the first grain to head out, was attacked very largely in this way. At LeSueur, June 28th, in a count of five hundred rye heads, Webster found 46.6% of the heads infested with *Macrosiphum granaria.* In a field of winter wheat six miles east of LeSueur 27% of the heads were infested when counted June 28th. Five hundred heads were counted in this case also. On July 19th, in this same field, 80% of the heads were infested, according to a count by Ainslie. On spring wheat, at LeSueur, July 19th, an average of 75% of the heads was infested with this grain aphis. Counts of infested heads on spring wheat at Cokato were made July 16th, showing 69% infested. On barley at the same place and date 48% of the heads were infested. At Atwater, July 17th, in wheat heads the infestation ran as high as 95% where the grain was dense and rank. In other parts of the fields where the wheat was shorter, the infestation ran about 20%. Barley at the same time was found infested to the extent of 25% and wheat 50% of the heads. At Marshall, on July 18th, 40% of heads of barley were found to be infested.

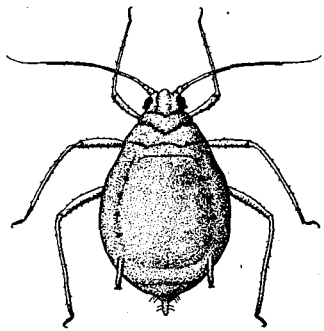

Fig. 7 Wingless viviparous female of *Siphocorynae avenae*. Original.

According to counts made by Ainslie the number of Aphids in wheat heads varied from one to twenty, the greater number of heads containing from one to five or six. On corn this aphis was found on the lower leaves, both on the upper and under sides of the leaves. In grain fields the infestation seemed to be greater on the higher and lighter soil. This was first noticed at Marshall, June 1st, in a field of oats. The aphis was found very commonly on higher ground, and only rarely on the lower ground. At Hastings this fact was also noticed. Counts of the number of infested heads in a field of rye at LeSueur, June 28th, showed 73% infested heads on high ground against 40% infested heads on low ground.

When the small grains mature this plant louse migrates to the volunteer grains and to grasses. During September it may be found on the heads and leaves of volunteer grains, *Panicum crussgalli,* Pigeon grass, and *Elymus canadensis,* as well as any young volunteer grains that may be up. It may be found on these plants during the whole fall, but as soon as the young volunteer grains and the winter wheat come up it migrates to them. The winter wheat furnishes an abundant food supply at a time when the parasitic enemies of plant lice are held in check more or less by the cold weather. The northern grain louse is thus enabled to multiply very rapidly. On the 24th of October Mr. Vickery found large colonies of apterous

females and young on winter wheat. They multiplied very rapidly, but did not become abundant enough to produce any very noticeable injury. Some parasitized individuals were present at all times, but the parasites did not become numerous enough to control the pest. On the 10th of December he collected apterous and winged viviparous females and young from winter wheat. A few Aphids could be found on almost every plant. Some parasitized individuals were found at this date. The temperature had been down as low as ten degrees above zero, and the Aphids had been covered with snow and exposed again as the snow melted. No sexual forms of the species were found, although careful search was continued until the advent of snow and ice.

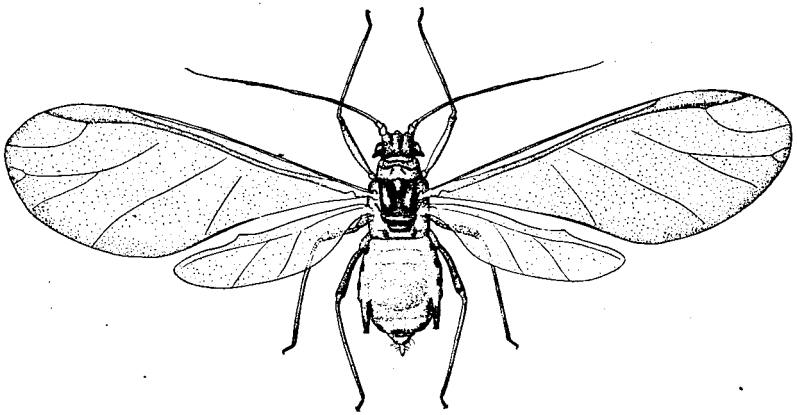

Fig. 8 Winged form, migrant, of *S. avenae.* Original.

Insectary notes show that there were at least fourteen generations up to November 8th, 1907, and that one adult may produce as many as forty-nine young. In addition to the fall food plants mentioned above, this species was also found on Poa pratensis, young timothy, fall rye and winter wheat.

Another form, common in our grain fields, is *Siphocoryne avenae,* Fab., The European Grain Louse, Figs. 7 and 8. This grain plant louse is one about which there

has been much controversy, some workers claiming that it is commonly found on the apple, it being referred to by them as the "common greenish apple aphis of the United States," which leaves the apple at about the fifth generation, and going to grains and grasses, returning to the apple in the fall, and depositing eggs thereon, which hibernate and give rise to stem mothers in the spring.

In the field we found this louse on the leaves of young wheat, oats, barley and rye during the first part of the season. Later it was found on the heads of these grains. After the small grains were cut it was found on pigeon grass and volunteer grains, and in the fall, winter wheat and rye. It occurred at Cokato, Rochester, LeSueur, Marshall, Breckenridge, Wolverton, East Grand Forks, Winnebago, Atwater, Worthington, Albert Lea and doubtless at many other places not visited.

Natural Enemies of the Green Bug and Other Grain Aphids.

All plant lice are not only influenced adversely or the contrary by weather conditions, but they are subject to the

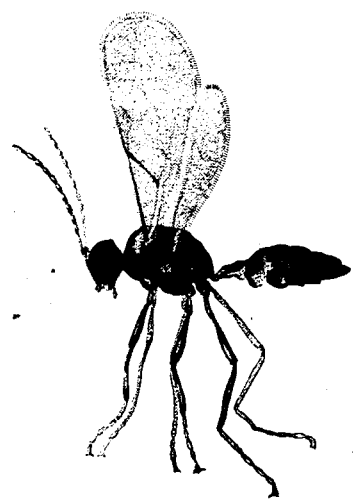

Fig. 9 *Lysiphlebus*, sp. a parasite on grain lice, enlarged about fourteen times. Original.

attacks of numbers of predaceous and parasitic enemies. Among the former are Syrphid flies, two winged insects, which place their eggs among the colonies, the eggs hatching into hungry maggots which consume large numbers of lice. The so-called "lady birds," beetles belonging to the family *Coccinellidae,* do the same thing, their grubs or young devouring enormous numbers of aphids.

Among their parasitic enemies the most prominent, in fact *the* parasite through whose work in normal years, both *Toxoptera* and *Macrosiphum* are kept in check, is a small four-winged hymenopterous insect, *Lysiphlebus tritici* which, upon the advent of warm weather in the South last summer, rapidly increased and reduced the hordes of lice. This insect we found here, last summer, and reared it repeatedly from *Toxoptera.* Unfortunately *L. tritici* does not reproduce freely at low temperatures; below 56° F. it is said to be inactive, or, as Webster puts it, it is active only when the temperature is twenty-five degrees above that

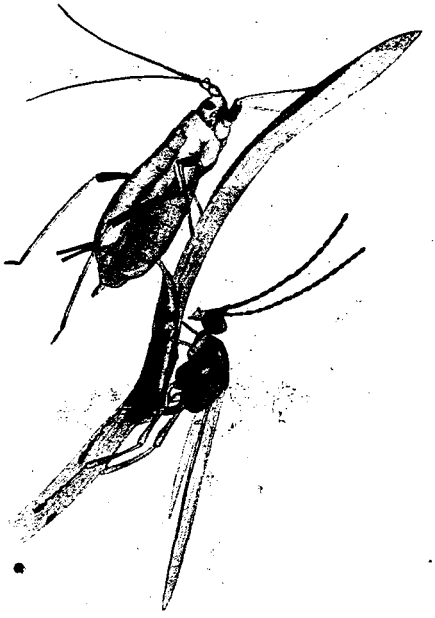

Fig. 10 *Lysiphlebus,* sp. attacking grain plant louse. From life. **Original.**

at which the green bug breeds freely. The method of attack on the part of this parasite is shown in Fig. 10, which was drawn from life by our artist, Miss Wood, and represents an individual of Lysiphlebus sp. in the act of ovipositing in a specimen of *M. granaria.* Normally *L. tritici,* as observed by us, approaches *Toxoptera* very deliberately, generally from behind, though frequently from the front, and oviposits with but little, or at least without effective resistance on the part of that louse; but *Macrosiphum* appears to be more on the defensive, and a foe requiring finer tactics. This may account for the method of attack as shown in Fig. 10. The egg placed in the body of the louse, hatches in a few days. The larva feeds upon the tissues of its host, preventing, it is claimed, any great production of young, and in this way, even before the death of its host, doing much to check the increase of the pest. Later, about a week from hatching possibly, the parasite has attained its full size, and with the proper light and magnification, can be distinguished through the body wall of its host, Fig. 11. The body of the louse swells, the individual dies, the skin darkens and hardens, and in a short time the little parasite emerges as a four-winged fly from a round hole cut in the abdominal wall of the dead insect, Fig. 12, prepared to mate and carry on the good work, if only the weather will permit. Millions of this genus of parasites are in our fields, working not only upon Toxoptera, when present, but upon some other plant lice, notably *Macrosiphum,* and in ordinary years are the principal means of keeping these pests in check. It is an encouragement to know that young lice destined to be winged, Fig. 6, are frequently parsitized; hence, when the imago migrant flies to other fields, it frequently carries the beneficial insect with it. It is worthy of note also in connection with the subject of parasitism, that *we find in Minnesota climatic conditions which are directly opposed to any disastrous outbreak of grain plant lice. In other words, we have cold winters and warm summers, the first factor preventing any undue increase of lice unattended by parasitism,*

and the warm summers allowing of a rapid increase of parasites before the lice have gained much headway.

Field observations through much of the grain-growing districts of Minnesota last summer brought out the following facts in this connection.

Eighteen per cent of the number of older aphids were parasitized in a field of rye at LeSueur, according to the counts made by Webster, June 28th. From this time on the parasites continued to increase until they reached their maximum in July. At Wabasha on July 9th 46% of the adult aphids were found parasitized and 76% were found parasitized at Dover, July 11th. At Cokato, Ainslie found 75% parasitized July 16th, and at LeSueur, July 19th, he counted 95% parasitized in a field of winter wheat. Under such heavy percentages as these the aphids could no longer withstand the attack, consequently their number decreased rapidly about this time.

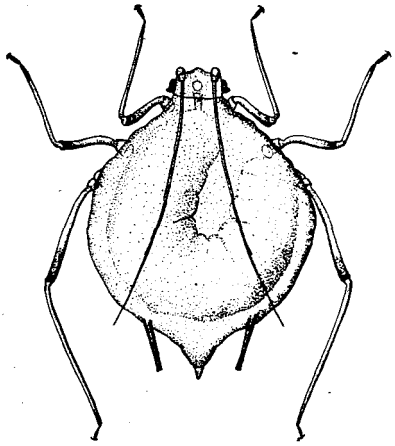

Fig. 11 A grain plant louse, *M. granaria*, in which the full grown parasitic larva can be seen. Original.

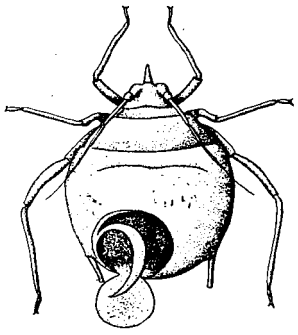

Fig. 12 A "green bug" killed by a parasite. Original.

Heavy rains in July probably gave the increase of the aphids a severe check, as well as the work of the parasites.

At Dover the grain aphis was reported very numerous on oats about July 5th. Webster visited the field

which was made the basis of our reports, on July 11th, and at this time found the insects only fairly numerous and heavily parasitized. Rains had occurred between the 5th and 11th of July, which no doubt had a part in checking the increase of the aphids. After several more rains had occurred, the same field near Dover was visited July 22nd by Ainslie, who reported that he could not find a single specimen of *Macrosiphum granaria* in this field. At Rochester a field of oats which was found very badly infested July 12th, when visited July 19th, did not show a single specimen. In the time between the two observations three heavy rains had fallen. Since only a moderate percentage of parasitism was found July 12th, the rains themselves must have killed the majority of the aphids.

Protective Measures.

Minnesotans, it would appear, need have no concern upon this point. Climatic conditions here are in our favor. It is not probable that we will ever be called upon to put in practice preventive measures in connection with either the southern form or its near ally, the northern species. The green bug in the South frequently appeared in a few spots in wheat fields, and appeared, in the beginning, to be confined to these spots. Advantage was taken of this to spread straw over these limited areas and burn same, thus killing the lice (and grain as well) and stopping their increase and spreading. They also plowed under these spots and harrowed and rolled them, packing the ground so firmly that the lice could not reach the surface. Spraying these spots with a 10% solution of kerosene emulsion was also tried with some success. It must be borne in mind, however, that even in the presence of such protection, winged migrants may come in from other non-policed fields and settle on the remaining wheat of the more careful farmer.

A weak point in the life history of *Macrosiphum* seems to be when it migrates from the mature small grains to volunteer grains and to grasses. The destruction of all

volunteer grains as well as such grasses as *Panicum crussgalli,* pigeon grass, and *Elymus canadensis,* that are found adjacent to grain fields, might considerably lessen the numbers of the aphids that would migrate to the small grains later.

Sexual Forms of Toxoptera Obtained in the Insectary.

We have not found sexual forms of the "green bug" in the field in Minnesota, nor have we been able to rear them outside in cages, but have had no trouble in getting this form in the insectary. Mr. R. A. Vickery, who has charge of our insectary work, reports them as being first found in the insectary on October 15th. They began laying eggs soon after this date, and continued for about three weeks. The winged males can be distinguished from the winged viviparous females by their somewhat smaller

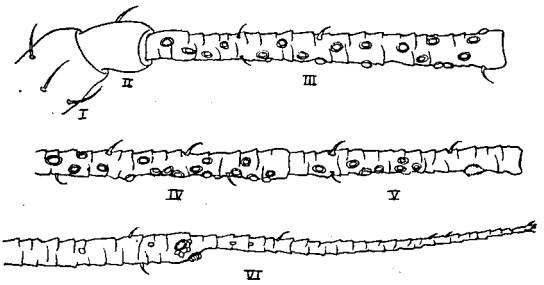

Fig. 13 Antenna of winged male *Toxoptera graminum,* x 120. Original.

size, and by the larger number of sensoria on the antennae. The oviparous females can be distinguished from the apterous viviparous females by their swollen hind tibiae, by the absence of circular sensoria on the antennae, and by the eggs which show through the abdomen as lateral, greenish yellow lines. The eggs which are bluish green when first laid, turn to a shiny black in a few days. They are about .65 mm. long, and .3 mm. broad. Most of them are laid on the upper side of the dead leaves of grain, but some are laid on the green leaves. Large numbers are placed on each leaf. Each female lays a comparatively

large number of eggs; ten nearly mature eggs were counted in one female.

Generations of viviparous females continue producing young during and after the appearance of the sexual forms. On October 25th we found on one pot of barley in the insectary males, oviparous females and eggs of Toxoptera, besides apterous and winged viviparous females and their young. Young were produced viviparously in the cold room as late as December, although the temperature had been down to ten degrees above zero. In insectary work here very few males appeared.

We append here a short technical description of the winged male and oviparous female, from specimens reared by us. This description was published in the February number of the Canadian Entomologist of the current year, and is, we believe, the first time these forms have been described.

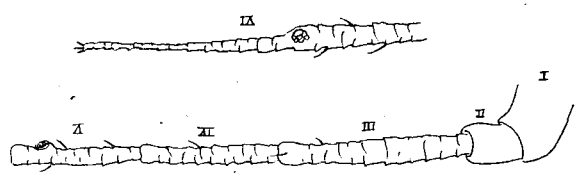

Fig. 14 Antenna of oviparous female *Toxoptera graminum*, x 120. Original.

Winged Male.—Fig. 3. Expanse of wings about 4.5 mm.; length of body about 1.3 mm. General coloration of the abdomen yellowish-green; head brownish-yellow; eyes black; antennae black except the two basal joints and the proximal half of the third, which are yellowish-green. Legs yellow, the femora more or less dusky, the posterior pair darkest; apex of the tibiae and tarsi black; cornicles yellowish, with black apex; cauda yellowish. Wings: costa and subcosta yellow; stigma paler, the inner edge of the stigma and the veins black. Antennae long and slender, reaching to or a little beyond the end of the body; third joint with about twenty circular sensoria; fourth with about eighteen; fifth with about nine. Cauda slender, somewhat constricted about the middle, as long as the cornicles. Lateral tubercles small and single.

Oviparous Female.—Fig. 4. Length 2-2.25 mm.; color, yellowish-green, median line of abdomen darker green; head and pro-thorax somewhat paler than the rest of the body. Eyes black; antennae

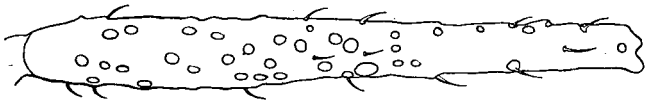

Fig. 15 Hind tibia of oviparous female *Toxoptera graminum*, x 120. Original.

black, except the two basal joints, and the basal half of the third, which are of the same color as the head. Legs yellowish, tibiae brownish toward the apex, tarsi black; cornicles greenish, their apex black; cauda greenish. Antennae slender, hardly one-half the length of the body, no circular sensoria. Cornicles slightly tapering, not reaching to the end of the body. Cauda slender, somewhat constricted above, the middle, about two-thirds the length of the cornicles. Tibia of hind leg swollen and thickly covered with sensoria-like swellings. Lateral tubercles small and single.

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