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GALL MIDGE

its Biology and Control

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The characteristic gouty enlargements on the lower surface of the veins of sugar maple leaves are familiar to many from the New England states to Kansas. In recent years this injury on maple leaves has increased in some localities in Missouri. A study of the gall midge which is responsible for this injury was begun in the spring of 1952 in response to complaints. While the pest does not seriously affect permanent health and vigor it does disfigure the foliage of this beautiful shade and ornamental tree and an effective control is therefore desirable.

GEOGRAPHICAL DISTRIBUTION

Workers were contacted in other states where the sugar maple grows to determine the distribution of the pest. It was originally described in the state of New York by E. P. Felt in 1911 from specimens reared in a jar containing maple leaves.

The gall midge's distribution seems to be confined to an area extending from the Atlantic Ocean, including southern Canada, to the Dakotas, Nebraska, and Kansas and south to Arkansas, Tennessee, and North Carolina.

Workers in a number of the states within this area report that they have never seen it and in no case do their reports indicate that it has been attracting as much attention as it has in recent years in parts of Missouri. It seems to vary greatly in abundance throughout its known range of distribution and also from year to year. Likewise, within a small area, such as a city block, it may attack 25 to 50 percent of the leaves on one sugar maple tree and scarcely appear, if at all, on others a few hundred feet away.

TREES ATTACKED

Dr. Felt originally described this gall midge in 1911 from "maple leaves bearing reddish tinted pouch vein galls ¼ inch long." Later in his 29th Report of the New York State Entomologist, 1915, he stated that it "was reared in the early spring of 1909 from jars containing soft maple *(Acer rubrum)* leaves bearing thickened pouch galls along the veins." He speaks of the veins often being reddish on the upper side but in his Figure 6 in Plate 2 of the same report the reddish galls are properly shown on the under-

**Dasyneura communis* Felt. (Diptera, Cecidomyiidae) side of the leaf. Further, he states in this same report, "There is grave doubt as to this species causing the galls mentioned above." This was probably due to the fact that he obtained the same midge from other jars containing various galls and debris. Felt's original association of the midge with the gouty vein galls on maple was correct because specimens reared by the writer from this typical gouty vein gall on sugar maple leaves in 1953 were found by Richard H. Foote of the U. S. National Museum to be *Dasyneura communis* Felt when he compared them with Felt's type specimens.

In his later reports Felt pictured these gouty vein galls on sugar maple *(Acer saccharum).* Some observers recently reporting on these galls list them only on the foliage of eastern soft red maple; others only on rock or hard or sugar maple; some on both maples. Under Missouri conditions the writer has found it only on sugar maple. Neither Norway nor soft maple trees in Missouri have been found with signs of attack by this midge. In the spring it synchronizes its emergence, from soil litter, very closely with the opening of the buds on sugar maple and the expanding of the first leaves. Clearly, in the Midwest, sugar maple is preferred by this insect though in the eastern states it seems to breed also on the soft red maple.

NATURE AND EXTENT OF DAMAGE

The tiny larvae after hatching on the lower surface of the leaf soon move to the upper surface and collect along the veins in groups of from two or three up to twenty-five. Here they set up some type of stimulation, probably by means of a larval secretion, along the upper surface of the main and branch veins. This causes a rapid cell development along the lower edges of the veins (Fig. 1). The result is the gouty thickenings which in a few days push upward almost closing off oblong pockets along the upper surface of the veins. In these pockets or galls the larvae feed and develop.

The galls are lined with delicate, thin-walled cells on which the larvae feed or from which they get their nourishment. From spring until late fall the galls continue to show this typical cell lining, and most larvae do not mature and stop feeding until just before or after killing frosts occur in the fall. The larvae are securely trapped in these galls until frost kills the leaves or until they fall to the ground and dry, causing the narrow slit along the upper surface of the gall to widen and thus permit the fully-developed larvae to escape and fall to the ground. The tightly closed galls protect the larvae quite well, though not fully, from parasitism and possible attack by predators.

The thickenings that form the galls develop along the edges of the veins and the adjoining margins of the leaf membrane in such a way as not to affect seriously the main portion of the veins. Seemingly, leaves with only a few small galls continue to function normally. But many leaves become so

Fig. 1—Maple Gouty Vein Gall Midge. Lower surfaces of leaves show severe crumpling by many galls (one-half natural size).

severely "galled up" that they become tied in knots, cease to function, and usually drop during the summer. However, one tree, kept under observation in this study for four years, with possibly half of its leaves containing some galls and practically every leaf on some twigs affected, has made a normal growth and seems none the worse from its four-year encounter with the pest. Under normal conditions, it apparently is not a serious threat to the health of sugar maple trees but it often does seriously disfigure the brilliant, ornamental fall foliage of this tree.

LIFE CYCLE AND DESCRIPTION

The insect spends the winter in the fully-grown, reddish, larval stage protected under moss and other ground litter, mostly beneath the maple tree on which it developed the previous summer. The larvae do not seem to enter the soil at all. By the last of January, 1953, these larvae began to spin thin, white cocoons outdoors and by the last of February all the larvae in the soil litter had spun cocoons. The first pupae in the cocoons were found on March 17. Adults began to emerge by April 10 and by April 22 hundreds, mostly males, could be swept from the grass. The first reddish eggs, in clusters of 15 to 100, were found hidden in the pubescence on the lower surface of the young expanding maple leaves on April 15. Eggs were laid only on the young, unfolding leaves and the adult female was observed inserting them among the leaf hairs by means of her ovipositor. Eggs began hatching by April 22 and the larvae promptly crawled to the upper surface and collected in groups of from a few up to 20 or more along the main and branch veins. At such points the swelling of the vein edges to form the galls began in the course of a few hours and in a few days the galls were fully formed. No eggs were deposited on older leaves and no galls formed along their veins.

ADULT

Adult males and females were reared by Felt in the early spring of 1909 and his descriptions of them appear in the Journal of Economic Entomology, 1911, Vol. 4, pages 478-479. His descriptions were made from dead specimens. Living adults show bright markings on parts of their anatomy not mentioned in the original descriptions.

During the study in 1953 the first adults emerged outdoors on April 10. Their peak of emergence occurred between April 20 and April 25. The last adults were taken on May 1.

At the height of their emergence 10 or 12 sweeps of an insect net close to the ground frequently took as many as 300 of the midges. A single inverted 8-inch battery jar, used for trapping the emerging adults, caught more than 100 in a day. There were far more males than females. The over-abundance of males was well illustrated at noon one day when close to 100 were found in a cluster mating and trying to crawl under the rim of the battery jar to reach other females trapped under the jar.

This midge is about the same size as the small black gnats found around potted plants in the home (Fig. 2). However, the reddish eggs showing through the distended body of the female give her a reddish color. Her egg-laying capacity was not determined, though it must be considerable. Some individual egg clusters were found to contain more than 100 eggs. In the act of egg laying she was seen to pass her eggs rapidly down through the protruded ovipositor and with but little apparent effort. These she always placed among the leaf-hairs on the lower surface of the young, unfolding leaves. Only a few days passed from egg laying until the galls were fully formed and even then the affected leaves were not fully developed.

Evidently it is only during the first few days of the life of the young, unfolding leaves that they lend themselves to normal gall formation. It is, therefore, only those leaves which are expanding during the short egg-laying period which develop galls. In 1953, all of the adults emerged and laid their eggs during a period of about three weeks, from April 10 to May 1, and it

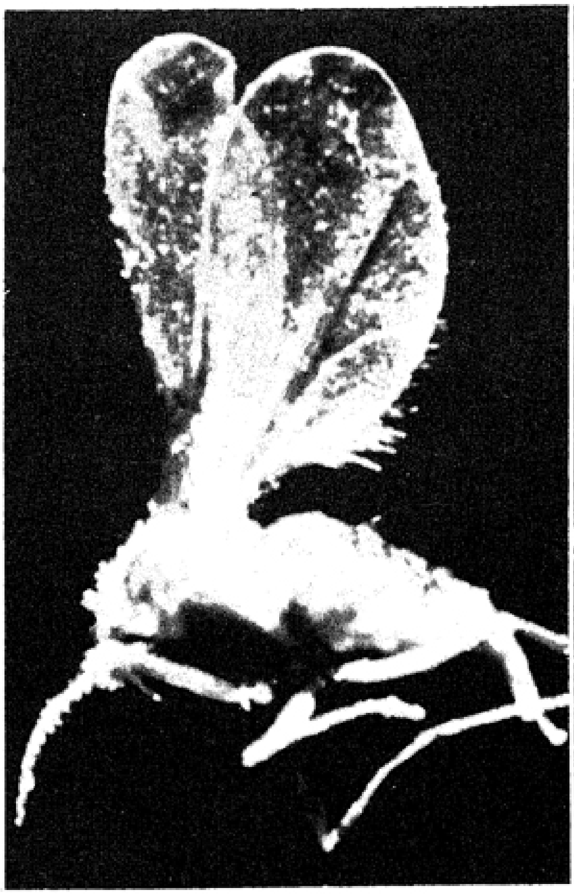

Fig. 2—Female maple gouty vein gall midge (X33).

Fig. 3—Maple gouty vein gall midge eggs (X 95).

was only the young leaves which unfolded during this period that became infested.

EGG

In 1953 the first eggs were found outdoors on April 15. For the next week egg laying increased rapidly on the younger unfolding leaves, and by May 1 the last of the eggs were observed. The period of incubation outdoors was from a week to ten days, for newly hatched larvae were observed along the upper surface of the leaves on April 22. By April 27 larvae were found by the dozen, collecting along the upper surface of the veins, and vein swellings had begun to appear. Heavy rain on April 29 did not seem to wash off the larvae. The first vein galls, completely enclosing the larvae, were found on April 29 on some of the young tip leaves. The four to six lower, older leaves on twigs showed no eggs or larvae or galls.

The eggs have a firm shiny shell and their contents are of a reddish color with a small bright red dot near one end. They are oblong in shape, about 0.26 mm. long and have a diameter of 0.085 mm. (Fig. 3). When securely inserted among the leaf hairs they are not easily dislodged by wind or rain.

LARVA

On first hatching among the leaf hairs on the lower surface of the leaves the larvae are little larger than the eggs and they have the same reddish color. Soon after hatching they move about and in a few hours begin collecting in groups along the upper surface of the leaf veins. At these points, in a short time, vein swellings begin to appear and the galls develop rapidly.

In 1952, when studies were made on the development of larvae and their galls, no signs of galls had appeared on any of the leaves on May 10. A week later, however, fully one-fourth of the young leaves showed vein swellings. At that time the young larvae averaged 0.43 mm. in length. For the next few days they seemed to increase in size slowly. By May 23 they averaged 0.51 mm. in length and 0.17 mm. in diameter. By the first of June they were 0.62 mm. in length and 0.21 mm. in diameter. As the season advanced their progress was followed closely but no effort was made to determine the number of larval instars. To observe them the galls had to be broken open which destroyed their future abode and any chance to follow an individual larva through complete larval life.

By July 1 they averaged 1.05 mm. in length and 0.32 mm. in diameter. By July 18 they averaged 1.11 mm. in length and 0.38 mm. in diameter. During the next month they grew rapidly. On August 19 they averaged 1.7 mm. in length and 0.58 mm. in diameter. During September they grew rapidly and rounded out their feeding and development. On September 26 they were mostly full-fed and, while varying greatly in length from 1.3 to 2.5 mm., they averaged 1.9 mm. In diameter they averaged 0.78 mm. (Fig. 4).

On October 6 and 7, two heavy frosts occurred, though some of the hard maple leaves and their galls remained green for several days. The foliage which fell soon dried, releasing the larvae. Also, the galls on much of the foliage remaining on the trees, some as late as October 25, began opening and releasing the larvae. By October 17 there were as many as 125 of the reddish maggots to a square foot of ground. A one square-foot pan, placed beneath heavily infested limbs from October 15 to 17, trapped over 200 larvae. The ground beneath this tree was literally alive with them and there was an abundance of overwintering material for completing the life history studies in the spring of 1953.

Larvae soon dried out and died in the warm, dry air in the laboratory. Outdoors in the ground litter neither the dry nor the cold conditions harmed them. Tests of their resistance to cold were made by placing infested leaves in a refrigerator at approximately 25° F for two days, and after warming them up the larvae crawled out of the opened galls and seemed normal. Others frozen solid in moist sand were normal when thawed out but when subjected to zero temperature for 24 hours they were killed. It is no wonder that they are able to survive our winters in ground litter without going into

Fig. 4—Maple Gouty Vein Gall Midge Larvae (X7).

Fig. 5—Maple gouty vein gall midge cocoon and pupa (X 20).

the ground for protection. After two cold spells with the temperature dropping to 15° F the larvae seemed uninjured on December 9. Winter mortality, however, due perhaps more to enemies than the cold, must be high for on January 13 an average of only 20 larvae to the square foot of ground litter was found.

PUPA

Larvae brought into the laboratory began to form their cocoons preparatory to pupating by mid-January. Outdoors, however, it was late February before the last of the larvae had enclosed themselves in their frail, whitish, oval cocoons (Fig. 5). At first it looked as though the larva in the last instar had simply separated itself from the next to the last instar skin, using it as a puparium as does the hessian fly. Later observations, however, revealed that when the cocoon was opened slightly the larva would mend the break in a few days. A cocoon containing a larva which was opened on March 9 was mended four days later and when reopened on March 17 it contained a pupa.

Larvae brought into the laboratory at a temperature of 70° F required about seven days to pupate after forming their cocoons. They remained in the pupal stage for another seven to ten days before adults began to emerge. At outdoor temperatures more time would undoubtedly be required.

In the laboratory the first adults emerged on March 6 but on the lawn the first adult was taken on April 10. Repeated samples of ground litter with larvae were brought indoors and after adult midges first began to emerge in the breeding cages they would continue to emerge for from five to seven days. For the next few days, however, about an equal number of hymenopterous parasites invariably emerged in these same cages. Apparently about half of the overwintering midge larvae were parasitized. They must have been attacked the previous fall for there were few, if any, days in February and early March when adult parasites could have been on wing attacking the midge larvae in the ground litter.

NATURAL ENEMIES

While this insect is able to maintain high populations on an individual tree for several years in succession, it does have its enemies and it is not equally abundant every year. Unfavorable weather for the short period in the spring, during adult emergence, egg laying, and larval establishment in the closed galls, is probably the most important natural check on the pest. High summer temperatures with the drying of the galls also serves as a check on it. Winter temperature and moisture do not seem to affect it seriously.

Besides weather, parasites and predators help reduce its abundance. Mites were seen to do some feeding on the eggs. The grain itch mite, *Pyemotes ventricosus,* was also found feeding on the larvae in partly opened galls on fallen leaves. A black species of thrips was frequently found in galls containing larval remains, usually along with some live larvae, though it was never found actually attacking the larvae. Both the earliness of the season and the shortness of the period of egg incubation and the establishment of the young larvae in the galls tend to limit attack at that time by either parasites or predators. Showers at that time did not seem to dislodge many of the eggs or young exposed larvae.

Once the larvae are securely enclosed within the galls, about the only enemies that can reach them effectively are the hymenopterous parasites. Some species attack and destroy them during the summer and fall while still in the galls. Others complete their work of destroying the larvae and pupae in the ground litter during the spring.

Of the various species of hymenopterous parasites reared from infested galls and from early spring collections of the larvae in ground litter, the following have been identified by Dr. B. D. Burks and Luella M. Walkley of the Insect Identification and Parasite Introduction Section of the United States Department of Agriculture: (1) *Pleurotropis tarsalis* (Ashm.) (Dr. Burks thinks it is possibly a parasite of *Gelis*); (2) *Gelis tenellus* (Say); (3) *Tridymus* sp.; (4) *Oxyglypta* sp.; and (5) *Tetrastichus* sp. Dr. Felt also reared a species of *Polygnotus* from these galls on soft maple.

While these small hymenopterous parasites do help to reduce gall-midge populations, these studies indicate that they fall far short of controlling the pests. Only a small percent of the midge larvae are killed by the parasites while feeding in the galls. On the other hand, in some of our breeding cages containing the overwintering larvae in ground litter, about as many parasites as midges emerged, indicating somthing less than 50 percent parasitism. Even so, thousands of midges emerged under the tree used in these studies.

INSECTICIDE CONTROL

Gall insects generally, and especially those attacking trees, are beyond the effective reach of insecticides. This species, however, is exposed to possible insecticide attack at two different periods in its life cycle. From late fall until the adults emerge the following spring the pest can be attacked with insecticides applied to the ground litter. Again for a few days the newly-hatched larvae are exposed to sprays on the surface of young leaves before the galls enclose them securely. Once the galls are tightly closed the larvae are quite thoroughly protected. However, by completely wetting the leaves with parathion or chlordane sprays the writer was able to kill a large percent of the larvae. DDT used in the same way gave little kill. Limited tests with systemics gave inconclusive results.

In these investigations, insecticides were studied (1) as treatments for ground litter; (2) as sprays applied when the eggs were hatching and the young larvae were still exposed outside the galls and (3) after galls were formed with the larvae inside. The first and second methods both had advantages and disadvantages but, all things considered, treatment of the ground litter has proved the most practical.

GROUND LITTER TREATMENTS

Most of the larvae escape from the partly dried galls in the fall before the leaves drop. Some may be carried by the wind in falling leaves a considerable distance before they escape from the galls. This, together with the fact that the beneficial parasites also are killed, are the two things which may prevent litter treatments from giving complete control of the pest. The treatment is simple, inexpensive, and safe for anyone to use. However, if children and pets play on the lawn, the treated area should be thoroughly sprinkled with the lawn hose.

Before making any lawn treatments, samples of ground litter containing the midge larvae were treated indoors in battery jars to determine the approximate dosages needed of the different insecticides. One 6-inch battery jar of litter was treated with ¼ teaspoon of 75 percent chlordane emulsion; another with 1 teaspoon of 1 percent chlordane dust; a third with ½ teaspoon of 40 percent toxaphene dust; two others each with ½ teaspoon of 50 percent DDT dust; and a sixth jar was left untreated as a check. The jars were watched for the next two weeks. A good number of midges emerged in the untreated jar but not a single midge or parasite appeared in any of the five jars treated with the insecticides. Then parasites were placed in the chlordane and DDT-treated jars and in both cases they were killed, never climbing above the litter on the sides of the jars. These dosages were far heavier than required, as shown by later lawn treatments, but they completely destroyed all insect life in the jars of litter.

For the lawn treatments, plots of 42 square feet or approximately one-thousandth acre were used. One of these received 2 ounces of 50 percent chlordane emulsion in 2 gallons of water; a second received 3 ounces of 40 percent toxaphene in 2 gallons of water, and a third plot received 4 ounces of 50 percent DDT powder. The plots were treated March 31, 1953, after a light shower and an hour later a light drizzle of rain fell.

Six-inch battery jars, used as traps, were inverted in the center of each plot and two similar jars were inverted near-by on untreated portions of the lawn. For the next 30 days the jars were checked for flies and parasites. Not a single fly or parasite appeared in either of the jars placed on the treated plots while hundreds of midges and many parasites were trapped in the jars placed over untreated spots. All three of these insecticide treatments, which were heavier dosages than commonly used for soil insects, apparently gave complete kill of all larvae, pupae, or adults in the ground litter. Apparently, if all the ground under an infested tree, and for a reasonable distance around the tree, is properly treated with one of these, or similar, insecticides, it should be possible to control the pest effectively.

FOLIAGE SPRAY TREATMENTS

Two separate foliage spray experiments were made. In the first, spray applications were made just as the eggs were hatching and before galls enclosed the young larvae; in the second, the galls were already formed, enclosing the larvae.

The first experiment included one test of 3 tablespoons of 5 percent DDT powder to a gallon of water; a second included 2 tablespoons of 50 percent wettable methoxychlor to a gallon of water, and a third included 2 tablespoons of 50 percent chlordane emulsion to a gallon of water. These applications were made on April 28, 1953, and the foliage was sprayed until it dripped.

The sprayed limbs were checked on May 4 and all larvae were dead and no further leaf-vein swelling had occurred where either the methoxychlor or the chlordane sprays were used. (Fig. 6). A few galls with larvae were found where the DDT spray was applied. Apparently it was too weak. Four days later, on May 8, almost complete control was still evident where methoxychlor and chlordane were used but some galls with live larvae were found where the DDT spray was used.

The second experiment, including one test with 2 tablespoons of 50 percent chlordane emulsion to a gallon of water, and a second test including 2 tablespoons of 50 percent wettable DDT to a gallon of water, was made on May 17 after galls were well formed, enclosing the larvae. In these tests, too, the foliage was sprayed until it dripped. Three days later few larvae were dead in galls treated with DDT but about half of those in chlordane-treated galls were dead. The hot dry weather that followed seemed to kill many of the larvae in galls not treated with sprays, so it was difficult to

Fig. 6—Maple gouty vein gall midge spray control. Right, leaf that was not sprayed shows galls fully developed. Left, leaf was sprayed and larvae were killed before galls were fully formed.

evaluate the final effects of DDT and chlordane. However, on June 13 one-third of the DDT-treated galls checked had no live larvae in them and on June 18 not a single live larva was found in 44 chlordane-treated galls. Spraying after galls are formed is clearly not a satisfactory control.

If it were not so difficult for the average person to determine those three or four days when the eggs are hatching, before galls form, and to get the trees sprayed promptly, foliage spraying with one of the chlorinated hydrocarbons or perhaps one of the newer phosphate insecticides should give adequate protection. But due to these drawbacks the application of one of the residual contact insecticides to the ground litter, either in late fall or early spring, offers more practical and economical control.

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