

10. Adults have been observed to emerge in an empty cage six feet from a manure pile, the pupæ having been produced by migrating larvæ. The greatest larval migration was at least eight feet.

11. In a naturally accumulated and infested manure pile larvæ and pupæ were overwintered. Adults continued to emerge during mild weather in mid-winter as long as manure was added. Emergence stopped when addition of manure ceased, but in spring at least 142 adults emerged.

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### SCIARA MAGGOTS INJURIOUS TO POTTED PLANTS

By H. B. HUNGERFORD, *University of Kansas*

During the winter months of 1912 numerous complaints were received concerning a tiny black gnat that was appearing in annoying numbers in conservatory windows and around the potted plants. In nearly every case they were held accountable by the housewife for the lack of thrift of many of her plants—an opinion not shared with any degree of assurance by the writer.

Upon investigation, the gnats invariably proved to be *Mycetophilid* flies of the genus *Sciara*,<sup>1</sup> and their shiny, black-headed white maggots were to be found in the dirt of some of the potted plants—sometimes in such numbers as to be turned out of the soil in small squirming balls.

Since this was the first time that these flies had been brought to our attention in this relation, we were not only at a loss regarding means of exterminating them, but, moreover, were skeptical as to the actual damage they were doing, being more inclined to attribute the sickly

<sup>1</sup> *Sciara coprophila*. The writer is glad to acknowledge his indebtedness to Dr. O. A. Johannsen of Cornell University for the identification of the flies and for placing at his disposal bibliographical material.

appearance of the plants to some physiological condition of the soil or surroundings.

The meager literature dealing with Mycetophilid depredations was scanned, and recommendations for control were made accordingly. It was very shortly discovered that the remedial measures given were decidedly ineffective when applied against these maggots, and, after running the gamut of the "suggested controls," we were compelled to admit to our friends that in the present state of our knowledge, we knew no satisfactory means of control.

To prevent any future embarrassment of the kind, the writer began a series of experiments, to determine the cause for the infestations, the nature of the injury, if any, the life-history and the control.

### LITERATURE

These insects have received but little attention from the economic entomologists, if we may judge from the literature. Most of the references are mere reports of their occurrence or injury. The gregarious migratory habit of some species has been reported from many quarters. Fifteen out of some thirty-five references relating to the biology of members of this family are devoted to noting this phenomenon. While the life-histories of but few have been reported, Beling (1),<sup>1</sup> Bezzi (2), Girard (9), Pastejrik (17), in articles not accessible to us, have dealt with the biology of various species of the genus.<sup>2</sup> Chittenden (5) gives the description of the larva and pupal stages, but the eggs were unknown to him and the length of the various stages not mentioned. Coquillett (6) describes pupation of *Sciara tritici* as occurring in an oval cell lined with a few silken threads. He also noted the eggs of this species as being scattered on the ground or deposited in clusters of twenty or more. He describes the eggs as oval, polished, white, and measuring about 1/10 of a millimeter in length. The length of the various stages was not known.

<sup>1</sup> See Bibliography.

<sup>2</sup> Since writing the above I have had the opportunity to review these papers in the libraries of Cornell University. Beling (1) gathered the maggots of twenty-four species from their breeding places in decaying wood, under fallen leaves in cow dung, etc. He describes the maggots and pupæ, giving in most cases the length of the pupal stage. In three instances he mentions the eggs but does not state the length of the incubation period. Bezzi (2) describes the eggs of *S. analis* as white, oval, twice longer than broad, and with such fine punctures that they appear smooth to the naked eye. The females lay from 200 to 240 eggs in more or less numerous clumps. The incubation period is given as seven days, the larval stage a little over a month and the pupal stage a week.—This article in Italian is perhaps the most complete account of the life history of any *Sciara*.

Dr. Johannsen, in his excellent work on the Fungus Gnats of North America, gives the description of forty-nine species in the genus *Sciara*, thirty of which are new species described by him, and four are not assigned. A few others are named, the descriptions of which are inadequate. Of these forty-nine species, rearing notes are given for less than a dozen. *S. multiseta* Felt, *agraria* Felt and *coprophila* Lintner were taken from mushroom cellars; *S. fulvicauda* Felt and *lugens* Joh. from decaying roots and wood; *S. pauciseta* Felt from decaying potatoes; *S. Hartii* Joh. and *cucumeris* Joh. from cucumbers, while *S. tritici* Coq. larvæ are reported as feeding in wheat, and *S. sativæ* Joh. was supposed to prey upon puparia of the Hessian fly.

In the species we have studied we have often seen the larvæ, especially the young ones, feeding upon the dead bodies of adults and pupæ of their own kind, but we have not observed them devour the living.

#### HABITS AND ECONOMIC IMPORTANCE

The family Mycetophilidæ, to which these flies belong, gets its name from the fact that many of them breed in fungi. The food of the maggots of most species consists of either fungi or decomposing organic matter. However, those of some species of the genus *Sciara* do, on occasion, feed upon living roots of plants. C. A. Hart<sup>1</sup> reports an experiment to determine the food preferences of the larvæ as follows:

A cucumber plant was potted in clear sand and one hundred of the maggots were placed about its base. These affected the plant, the stem evidently being eaten by them. The same experiment was made with the addition, at one side of the pot, of a cubic inch of decayed horse manure, such as is mixed with earth in growing cucumbers. The larvæ were subsequently found collected about the piece of manure and the plant remained uninjured. Next, a plant was potted in a mixture of manure with earth from the forcing bed infested by maggots. The plant was not injured.

His conclusions are that injury to living plants results only where larvæ are excessively abundant. He further states that:

In no case were the maggots found attacking a firm, healthy stalk or root of the cucumber plants, but at the least appearance of decay they attacked it in great numbers, gnawing the surface and tunneling through it in all directions.

It was our belief that such would be the case with those species we have studied. But, during the past five years, under all sorts of soils and conditions brought to bear in the flat glass root cages, we must state that it has been our observations that they will attack healthy roots even in pure, well rotted manure and in soils with the optimum amount of dried blood fertilizer. We have frequently watched them

<sup>1</sup> Experiment by Mr. Green recorded in 26th Report of State Entomologist of Illinois.

eating the root hairs of various rootlets and devouring sound, growing roots.<sup>1</sup>

Dr. Johannsen states that:

Florists look upon these little gnats with a suspicion which is more than justified, as the fact that the larvæ feed upon the tender roots of potted plants is well established.

He further states:

I have found larvæ in potatoes, feeding on the sound tissue, on the roots of various grasses, and in tulip bulbs.

The maggots of those species we have studied are almost omnivorous as to feeding habits and the injury to plants becomes apparent only when they are relatively abundant. We have watched a maggot as it devoured the dead pupa of one of its own species, nibbled at flakes of decaying organic matter and then, coming to a live healthy root of a wheat plant, proceed to devour it, following its windings for some distance, eventually eating all of the three inches of root that lay against the glass. Maggots newly hatched seem to prefer the root hairs and often clean a rootlet for some distance, and then work upon its surface.

An examination of the root system of an infested plant often shows it severely curtailed. In Plate 42, figure 6, is the photograph of a geranium where the maggots were abundant. Plate 42, figures 1 and 3 show their work upon a geranium slip.

There can be no doubt as to their injurious work.

This lack of thrift of house plants is more often due to the work of these maggots in the soil than is commonly supposed. Plate 42, figure 2, shows some geraniums that have been injured. In one large conservatory the majority of the plants were ruined. Among them were a beautiful eleven-year old fern, many begonias, colias, etc.

Drs. Chittenden, Hine, and others have reported injuries to peas growing in flower pots, and to lettuce, cucumbers and carnations. Dr. Hine states that they were living in the stems of the carnations. Dr. A. D. Hopkins has called attention to their work upon potato tubers. Dr. Forbes has called attention to their injury to seed corn, and the roots and bulbs of various kinds of flowering plants. Coquillett and Lintner mention them as being injurious to wheat, and we have in our own economic collection of insects, some *Sciara* specimens taken from wheat fields at Solomon, Kansas. They have been several times reported as working upon grass roots and we have found them

<sup>1</sup> These observations have been corroborated by Dr. Charles A. Shull, Associate Professor of Plant Physiology, and others.

boring in the crown of both clover and alfalfa, which leads us to believe that their economic importance has been somewhat overlooked.

### LIFE-HISTORY

*Technique Used.*—The first studies in life-history were attempted by rearing the flies in small potted plants. Here, however, it was difficult to locate the eggs and impossible to observe the maggots. For studying the actual work of the maggots on the roots of plants, a flat glass device was used. This was filled with dirt and a geranium slip started. When this breeding box, shown in photograph Plate 41, figure 8, was placed on its side, some of the roots would come to lie against the glass. Thus when the maggots were found eating the roots, the whole device could be inverted and examined under binoculars.

The fact that the maggots fed upon roots suggested the possibility of carrying the life-history through on slices of potato in petrie dishes. The data for the life-histories were obtained by following the various stages on slices of potato in this manner, or in small potato cones in test tubes.

Dr. Robertson suggested that I sterilize potato in the auto-clave and add yeast—a modification of the banana and yeast plan employed by breeders of *Drosophila*. I reared one brood through in this fashion in thirty days.

Broods were reared in the soil of potted plants as a general check on the length of the life cycle.

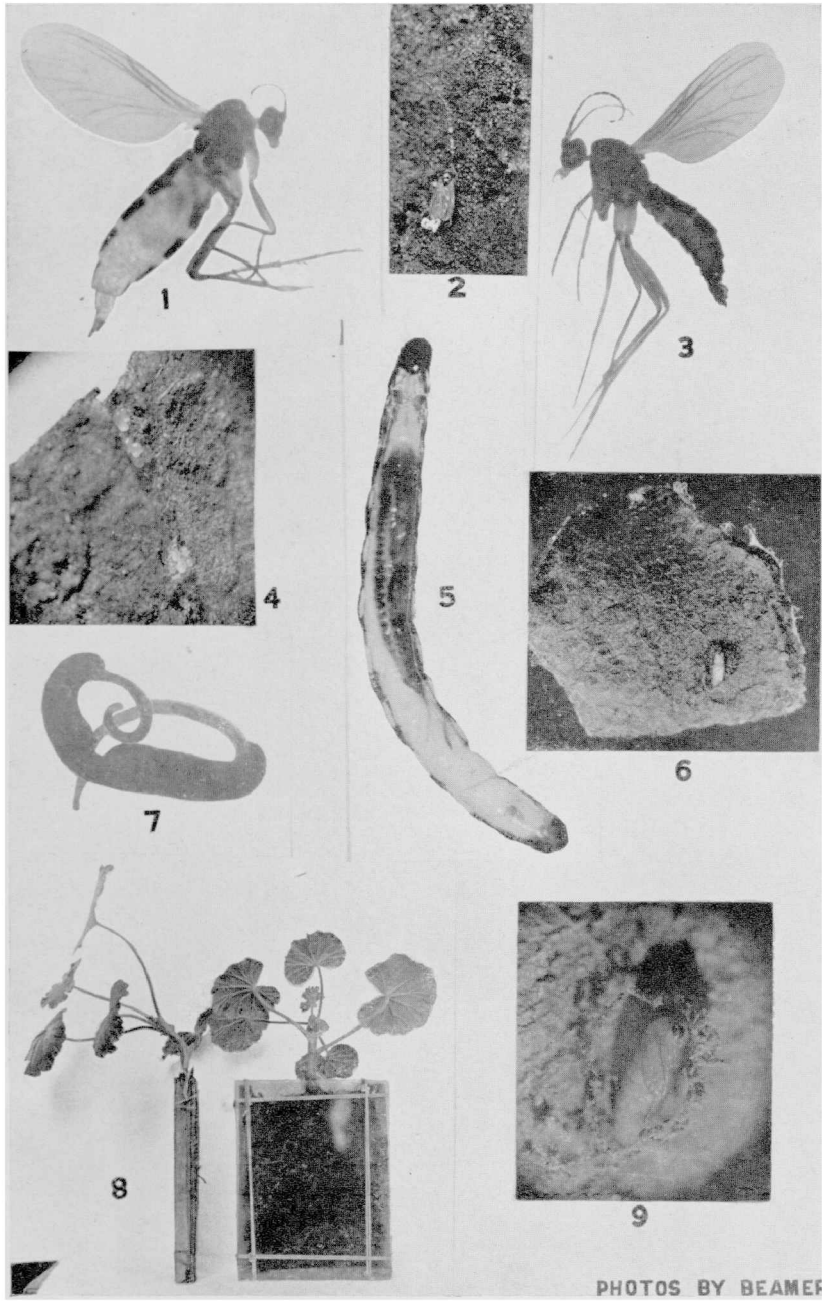
### STAGES IN LIFE-HISTORY

The entire life cycle from egg-laying to egg-laying takes from twenty-four to thirty-two days. The adult female often begins ovipositing the day following her emergence. The egg stage and the pupal stage are quite constant as to the length of period, but an irregularity of several days frequently occurs even among the maggots hatching from one egg clump.

### THE EGG

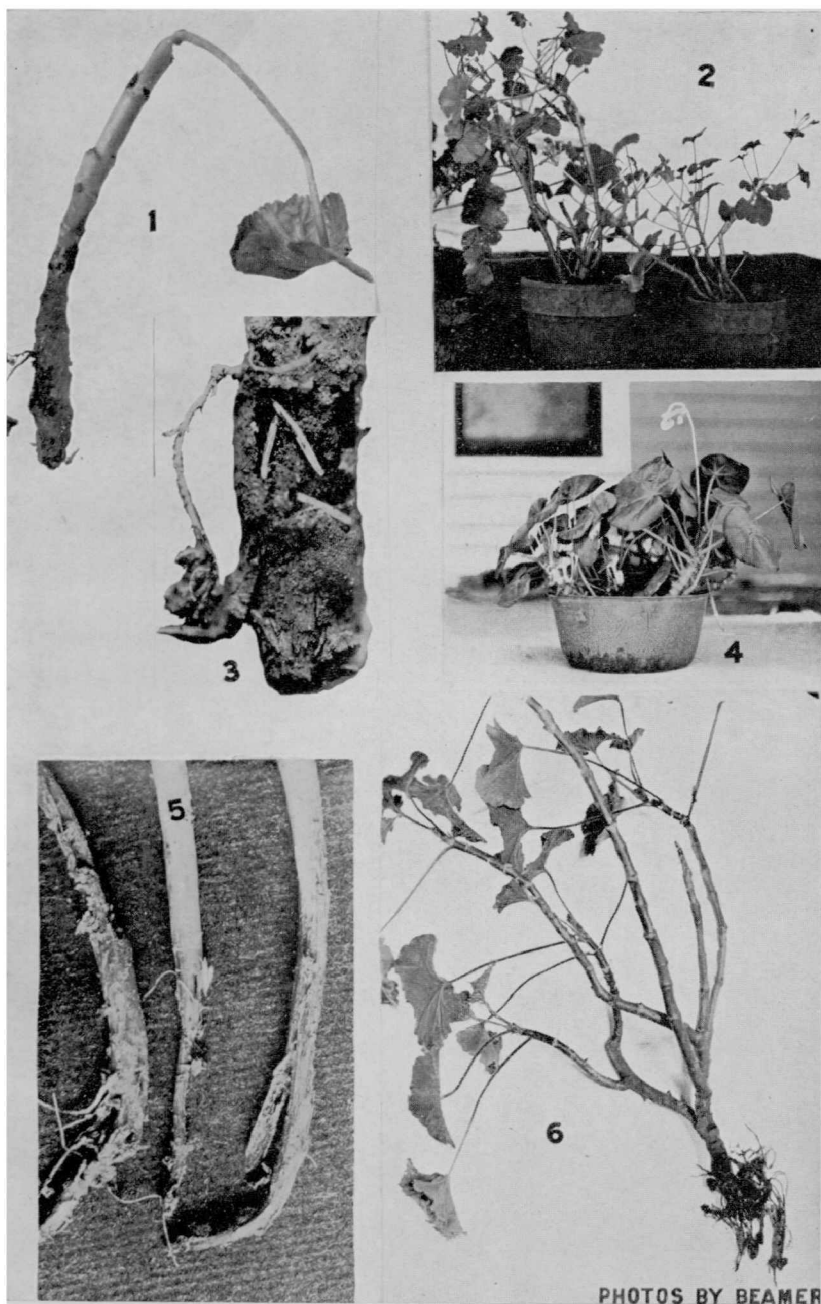
The females lay from about seventy-five to one hundred and seventy-two eggs. These eggs are placed in declivities or irregularities of the soil. Often, where the soil has drawn away from the pot or the plant stalks, the female will follow down these crevices as far as possible and oviposit there.

The eggs are usually laid in clusters of from two or three to more than thirty. Individual eggs are oval and measure .24 mm. in length by .12 mm. in width. Clusters of them are quite plainly visible to the unaided eye. When first laid, the egg is of a pale greenish-yellow



PHOTOS BY BEAMER





color, but turns to pearly white in the course of a couple of days. About this time the head of the future maggot shows up as a shadowy patch that grows darker until by the end of the fifth day it is black and shiny and the embryo is active within this chorion. The eggs hatch in six days. In Plate 41, figure 4, is shown some egg clusters as they were laid in a small crevice of a potato; and Plate 41, figure 2, shows a female in act of laying—about two times natural size.

#### LARVA

The larva when first hatched measures .65 mm. in length and is transparent. As soon as it begins to feed, the digestive tract shows as a dark line through the body. As it grows the body begins to take on a white color which is due to the large fat bodies within. *Sciara* maggots are characterized by their white bodies and black shiny heads. When grown the maggots measure about six or seven mm. in length and have the appearance shown in Plate 41, figure 5. About the eleventh or twelfth day, they begin to spin their cocoons which consist of a few threads of silk binding together loose bits of earth, fibre and the like. Larvæ of all stages have the power to spin out sheets and fibres of silk and sometimes use this power to form a cover to a tunnel in which they work. The larva preparing for pupation spends twelve hours or more making a very flimsy cell which is only a little more than two-thirds its length.

#### PUPA

Before pupating, the larva contracts to about 4 mm. and after a quiet period of some hours, changes to a naked pupa which is milky white in color. This gradually changes until just before emergence of the adult, the thoracic part is black and the abdomen shows the pattern of the adult. The pupal stage lasts from five to six days. Pupation usually takes place near the surface of the soil, though pupæ are not uncommonly found deep down in the earth—indeed, adult flies are sometimes found imprisoned in deep spaces. The pupæ usually work their way to an open space before coming forth as adults. For this reason the surface of infested soils are often strewn with empty pupa cases.

#### ADULTS

The adult male and female of *Sciara coprophila* are shown in Plate 41, figures 1 and 3. These photos show their relative size and characteristics.

The female of this species measures about 3 mm. and the male measures 2.5 mm. Both are very active and are rapid runners though weak flyers. They are prone to hide under bits of earth or leaves on



the surface of the pot and "play possum" if disturbed. They are often found in houses where a few plants are kept during the winter months, and, as a rule, cause little concern. However, when they are being bred in large numbers in the favorable soils of the conservatory, they become a nuisance invading all parts of the house and at this time become especially annoying on the dining table where their accidental landing in butter and cream becomes somewhat trying to even the less fastidious.

### CONTROL MEASURES

The experiments for the control of these insects involved: 1st, protecting the plants by the use of repellents; 2d, destroying the maggots in the soil by the application of contact insecticides and stomach poisons; 3d, destroying the adult flies by the use of traps and poison baits.

### REPELLENTS

In this series of experiments, small geraniums in three-inch pots were used. The surface of the soil was covered to a depth of from one-fourth to one-half inch with various substances such as flowers of sulphur, pyrethrum powder, coarse sand, etc., and then exposed in a place where there were many flies and other similarly potted plants as checks. All of these plants were watered with like quantities of water and watered from the saucers. The results were not startling, though there were one hundred and fifteen dead flies near one pyrethrum pot. When the soil was examined the average number of maggots per pot were as follows:

Pyrethrum . . . . .	5
Dried blood . . . . .	114
Sand . . . . .	0
Sulphur . . . . .	0

From subsequent experiments it is evident that the attractiveness of the dried blood might have lowered the other counts somewhat. For in this connection it may be stated that as a result of exposing plants whose soils contained dried blood fertilizer and plants whose soils were ordinary garden soils, the ratio was an average of seven hundred and fifteen maggots per each pot to seven maggots. The larger number appearing in the soils containing dried blood.<sup>1</sup>

<sup>1</sup> One three-inch pot used in this as a trap was exposed a few days and then the surface of the soil carefully searched for eggs. The egg clusters were more numerous in a crevice between the pot and the dirt and in a similar place at the base of the plant on the shady side. The eggs in this case were arranged in clumps as follows: 8, 7, 5, 1, 15, 20, 15, 9, 21, 5, 9, 3, 5, 10, 16, 5, 7, 5, 2, 9, 5, 6, 3, 7, 2, 15, 8, 6, 2, 1, 3, 17, 5,—a total of 252 eggs, an average of 8— eggs to the cluster.

It was early noted that the flies showed a marked preference for soils having an abundance of moisture. Plants alike in every particular save in the amount of water received showed in one series an average of seventeen for the wet ones and none for the dry—a good suggestion for control, for besides rendering the soil unattractive to adults, the maggots already in the soil perish. However, many plants will not stand the lack of water and so experiments were made to see how well control could be affected by sanding the surface of the pots and watering from below. Besides presenting a surface unattractive to the egg-laying of the adult, the inability of the larvæ newly hatched to get down through the sand was demonstrated.

It also appears that pupæ already found in the soil have difficulty in getting through the relatively dry sand barrier. One hundred pupæ were placed in each of six pots, three of which were covered with one-half inch layer of rather coarse sand and water supplied from below. The counts were 3—1—0, for sanded pots and 97—92—94 for the check pots.

The depreciation in the former case may be normal mortality, or it may mean that some were injured in transferring them to the pots. In practical application of this method under conditions prevailing in our homes where ferns and begonias often predominate, the judicious combination of the methods above noted have given very satisfactory results.

In all the cases that have come to our attention, the presence of these flies has seemed due to soils rich in barnyard manure or treated with dried blood fertilizer. In one instance a lady who found that a large potted Lantana was supplying the flies that had been noticed all the fall, thought to help matters by emptying the remains of the tea-pot upon the inch of sand that had been placed on the surface of the soil. Some time later we were called in to see where the flies came from. A three-fourths inch layer of tea leaves was found, in the lower layers of which were hundreds of maggots. The maggots had gnawed the base of the tree somewhat but there did not seem to be maggots or pupæ in the sand below. Remedial measures were simple enough.

#### DESTROYING THE MAGGOTS IN THE SOIL

All of the first efforts at control were directed toward destroying the maggots as they existed in the soil. The recommendations found in the literature were followed but with slight success. These included the use of lime water, kerosene emulsion, hellebore, carbon bisulphide, etc., and to this list were added experiments with: Black Leaf 40, in strength from one part to 1,000, and one part to 100. Sodium thio-carbonate, whale oil soap, borax water, and experiments in which the

soil was saturated with solutions of lead arsenate, Paris green and the like.

Two series of experiments were employed in the above; one with potted plants, soil of which contained maggots, and another in which slices of potato covered with the maggots were embedded in pots of sawdust, thus making simple the observations of the effects of the material used. The results in all of these cases either failed to kill the maggots or injured the plants.

It may be worthy of note here that Hart reports that a solution of from one-half to six per cent of nicotine brought about premature emergence to the flies, thereby destroying them. He also states that the preparation repelled the larvæ. His work was with cucumber beds in a forcing house. The trouble here arose through the use of comparatively fresh manure as a fertilizer. He noted in this connection that when the manure was well rotted little or no injury followed.

It is to be hoped that the work now being done in various laboratories with nitrobenzene will lead to the discovery of some satisfactory applications for killing underground insects.

#### DESTROYING THE ADULTS

Many flies were killed by the use of the following recommended by Sanders in "Minnesota Insect Life":

One-sixth ounce of sodium arsenate dissolved in a gallon of water and a pint of molasses. The flies preferred this mixture to combinations of it with stale beer and orange juice. The plants were allowed to become dry and then the sweetened mixture was sprayed over them with a syringe. They fed upon it greedily. However, under ordinary conditions, complete control could not be effected for the flies were not strongly attracted to it.

We had hoped to try the paradichlorobenzene so strongly recommended a year ago, but have been unable to obtain it even for experimental purposes.

#### NATURAL ENEMIES OF SCIARA FLIES

In two references in literature that have come to our attention, certain *Sciara* maggots have been accused of parasitism. Mr. Peter Cameron 1875(3) declares them to be internal parasites of Sawfly larvæ. He states that the latter retain sufficient vitality to spin a cocoon inside of which the fly larvæ completes the destruction of their victims. Later, they quit the cocoon and change to pupæ in the ground.

Much later than this, *Sciara* was credited with preying upon Hessian fly puparia. If these cases are authentic, it is a step beyond the usual scavenger tendency we have so often observed.

However, *Sciara* maggots and adults are the hosts of a few forms. W. R. Thompson (19) gives an article "Sur un diptere Parasite de la larve d'un mycetophilidie." He found some *Sciara* maggots infested with parasites which he argues must be larvæ of a "Dexiid" or more probably of a "Tachinid."

In one series of experiments we had a number of three-inch pots of geraniums containing some dried blood fertilizer which were being used as a trap pot in a place where the flies were abundant. One pot sat in the corner of the infested bed and here a small nymph of an assassin bug (*Milyas*) took its abode, with the result that during the nineteen days of its presence there, it quite effectively kept the pot free from eggs.

In our study of the development of the eggs, we were at one time troubled by the predatory tendencies of a small mite which unfortunately we did not preserve for identification.

These same mites were seen to attack living flies, the wings of which held them captive to the moist glass.

There is, however one parasite, a nematode, that most efficiently reduced my stock of flies to the vanishing point just recently. It works within the maggot and reaches maturity there. Though the parasite occupies most of the space within the maggot, the latter is sometimes permitted to become an adult, minus, however, all traces of its organs of reproduction. Plate 41, figure 7, shows an adult female parasite. The life-history of this nematode and its effect upon the host will appear in another publication.<sup>1</sup>

#### SUMMARY

The life-history of *Sciara coprophila* requires a period of from twenty-four to thirty-two days. The egg stage occupies six days, the maggot stage twelve to fourteen days, or longer, the pupa stage six days and the adults have lived under laboratory conditions about a week. The maggots, though omniverous feeders, are injurious to potted plants through their feeding upon the roots and root hairs.

Soils that are moist and rich in manure or dried blood attract the flies and lead to the laying of large numbers of eggs in these favored situations, the result being that plants growing in soils of this character are seriously damaged.

The maggots, though resistant to most insecticides, quite readily succumb to drying. Thus, by letting the soils dry out occasionally, little trouble will be experienced. Where a serious infestation occurs, a judicious drying out of the soils, use of dry sand on top of the dirt, and trap pots of dried blood and earth and sprouting grain used to attract egg-laying, will effectually control the pest. The maggots

<sup>1</sup> See also Bezzi (2) for others.

and eggs in these trap pots should be destroyed about every two weeks by submerging in boiling water.

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#### PLATE 41

- Figure 1. Female *Sciara coprophila*.
- Figure 2. Female ovipositing showing the wings in nearly their normal position.
- Figure 3. Male *Sciara coprophila*.
- Figure 4. Eggs of *Sciara coprophila* deposited in a crevice in the upper surface of a bit of potato tuber.
- Figure 5. The maggot of above named fly.
- Figure 6. Pupa on surface of potato showing the nature of its pupal chamber.
- Figure 7. Adult ♀ nematode with egg capsule dissected from an infested maggot.
- Figure 8. Device for studying the food habits of the maggots.
- Figure 9. Enlarged view of pupa shown in Figure 6, to show the chamber of bits of foreign material tied together with silk fibres.

#### PLATE 42

- Figure 1. Geranium slip killed by the work of *Sciara* maggots.
- Figure 2. Geranium plants that owe their straggly appearance to the work of the maggots in the soil.
- Figure 3. Close view of lower portions of plant shown in Figure 1.
- Figure 4. Begonia plant in a poorly drained vessel with a soil rich in manure. An ideal place to breed *Sciara*.
- Figure 5. Corn roots riddled by the maggots.
- Figure 6. Geranium plant and its curtailed root system.

## NOTES ON THE CONTROL OF THE WHITE PINE WEEVIL

By S. A. GRAHAM

Yearly the white pine weevil, *Pissodes strobi* Peck, takes its toll of young white pines and Norway spruces, and in recent years it has received considerable attention not only from entomologists, but from foresters and nurserymen as well. A number of control measures have been suggested, some of which are undoubtedly valuable under favorable conditions.

During the past season the writer has applied different materials at various strengths as sprays and washes to the young pines, in an