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THE SATIN MOTH:

AN INTRODUCED ENEMY OF
POPLARS AND WILLOWS

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Rows of 25-Year-Old Carolina Poplars. A favorite food of the Satin Moth

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THE SATIN MOTH: AN INTRODUCED
ENEMY OF POPLARS AND WILLOWS.

DISCOVERY OF AN UNWELCOME IMPORTATION.

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The satin moth (*Stilpnotia salicis* L.), a well-known insect in Europe, was first reported in the United States about July 1, 1920. A crew of men employed by the Metropolitan Park Department found a number of Carolina poplar trees located on the Fellsway at the Malden and Medford city line just north of Boston that were being defoliated. The gipsy moth was first suspected as the probable cause of the trouble, but specimens were later collected by the foreman and turned over to Mr. A. N. Habberley, the park superintendent. As he did not recognize the caterpillars, he brought them to the Gipsy Moth Laboratory at Melrose Highlands. They did not seem to be a native species, and accordingly Mr. S. S. Crossman, one of the assistants at the laboratory, visited the insect collections in Boston and Cambridge and was able to identify the insect as the satin moth by comparison with larvæ in the collection of the Museum of Comparative Zoology at Cambridge, Mass. Confirmation of the determination was later secured from specialists at the United States National Museum. As this insect is closely related to the gipsy moth and the brown-tail moth, having habits which are similar in some respects to those of each of these species, considerable anxiety was felt as to the amount of damage it might cause.

The caterpillars were nearly full-grown at the time they were found and some of the trees were badly defoliated. A hasty examination showed that the most severe defoliation was in the region where the caterpillars were first reported, and several trees in a small group of Lombardy poplars were completely stripped. (Fig. 1.) A row of large California poplars directly in the rear of a number of houses were being heavily eaten and the owners complained bitterly about the superabundance of caterpillars which invaded the houses and made life extremely disagreeable, as they frequently crawled upon the tables and even on the beds, and in spite of all the care that could be taken it seemed impossible to keep them out. The sides of these houses nearest these trees were heavily stocked with larvæ, particularly under the eaves and clapboards, and in a few days many of them began to pupate.

CONTROL WORK UNDERTAKEN.

As soon as the identity of the species was determined, arrangements were made with the superintendent of parks and with the State forester's office, which in Massachusetts has charge of the gipsy-moth control work, to cooperate with the Bureau of Entomology. No special funds were available for the purpose, but work was undertaken to reduce the damage and danger of spread as much as possible

until more complete information as to the nature and possibilities for destructiveness of the insect could be determined.

Arrangements were made that the Park Department should destroy as many of the caterpillars and pupæ as possible on the trees along the Parkway which were under its control; that the State

FIG. 1.—Row of Lombardy poplar trees, the three on the left completely defoliated by the satin moth (*Stilpnotia salicis*); the others partially defoliated. July, 1920.

forester's office should examine the residential property in and around the center of infestation and destroy the insects thereon, and that the Bureau of Entomology of the United States Department of Agriculture should scout as much as possible of the outlying territory to determine the extent to which the insect had spread, secure

field and laboratory data on the habits and life history of the insect, and obtain all possible information on the best methods of control.

Accordingly, the Park Department immediately sprayed the trees along the Parkway in and about the worst infested part of the territory; but, owing to the fact that most of the larvæ were nearly full-grown, the treatment was not very effective. It also employed a crew of trained gipsy-moth men to patrol the trees and crush all the larvæ within reach. Later these men were kept busy crushing pupæ and treating the egg masses with creosote.

At the same time assistants from the State forester's moth force carried on similar work on the privately-owned grounds adjoining the Parkway and large numbers of the insects were destroyed.

The scouts supplied by the Bureau of Entomology commenced an examination of the surrounding territory, particularly where poplar or willow trees were present; but as scattered, though small, infestations were found each day, they began working in towns more remote from the center.

Investigations were also begun by experts from the Gipsy Moth Laboratory, and such time as could be spared during the busiest season of the year was devoted to a study of the behavior of the insect in the field, its food plants and enemies.

As soon as the moths began to emerge as many as possible were crushed, but as quantities of the caterpillars pupated within curled-up leaves on the trees, the method was only partially effective. Both sexes of the moth fly readily and are attracted to brilliant lights. Observations at night materially assisted in securing records of the spread of the insect.

THE INSECT, ITS DEVELOPMENT AND HABITS.

During the summer of 1920 the following facts were learned concerning the insect:

THE MOTHS.

The insect derives its name from the white, satinlike appearance of the moths (fig. 2), which are larger than most of the white moths native to New England and have no colored markings on the wings.

The males are 15 to 20 mm. in length and the females 20 to 25. The head, thorax, and abdomen are black but densely covered with long white hairs, so that they resemble the color of the wings, which, as stated, have a satiny luster. The eyes are black. The legs are black and the femora are densely covered with long white hairs. The tibiæ and tarsi are sparsely covered with white hairs and ringed with white overlapping scales which give the appearance of alternate bands of black and white. The dorsal side of the antennal shaft is white, the pectinations brown to black. The expanse of the forewings is from 35 to 55 mm. The females usually are slightly larger than the males.

THE EGGS.

The eggs are laid in somewhat elongated patches 13 to 22 mm. in length and covered with a white secretion which holds them together

in the cluster. (Fig. 3, *B, C.*) They are very conspicuous and are easily distinguished from the egg masses of other moths. Dissections show that a female usually produces about 550 eggs, although some

FIG. 2.—The satin moth: Male above, female below. Enlarged.

individuals lay a larger number. If the female is disturbed she frequently deposits more than one cluster. She may fly from the place where egg laying was begun and continue the operation in another locality. Although the eggs are usually laid on the underside of the

FIG. 3.—The satin moth: *a*, Poplar leaf partially skeletonized by small larvæ (small larva shown below leaf); *b*, egg cluster on leaf; *c*, egg cluster on bark.

leaves and on the branches and trunks of the trees, they are sometimes deposited on grass, weeds, or stones, and even on the ground if no more convenient place is available.

In 1920 the first eggs were observed in the field July 6, and an unhatched cluster was found as late as August 10. This indicates that egg laying sometimes continues for about a month. Most of the eggs were deposited about the middle of July.

Hatching takes place in about 15 days after the eggs are laid, but this period is frequently shorter if the weather is hot.

THE LARVÆ.

First-stage larvæ.—Newly hatched larvæ are 2 mm. long. The head is brownish black, provided on front with a few short spines, the mouthparts lighter in color. The body is brownish yellow, with rows of slightly darker tubercles, which are thickly studded with short brown spines and with a small number of long hairs. Molting takes place in five or six days.

Second-stage larvæ (fig. 3, A).—Larvæ of the second stage are 4 mm. in length. The body is brownish black, except the dorsum of the second and third thoracic and the third, fourth, fifth, eighth, and ninth abdominal segments, which are yellowish white. The dorsum of the sixth and seventh abdominal segments are each provided with a retractile tubercle. All tubercles except the latter are thickly studded with short brown spines and a few long hairs. After feeding five or six days the larva molts again.

Third-stage larvæ and their hibernating pockets.—In the third stage the larvæ are 6 mm. in length. The body is slightly darker in color than in the preceding stage and the tubercles are similarly arranged. This makes the light colors on the dorsum more conspicuous. The larvæ immediately seek shelter and begin the construction of a small web, in which they hibernate. As a rule these are made individually, but occasionally two or sometimes three larvæ will be found in one of these hibernating pockets. Crevices or uneven places in the bark are sought by the larvæ, and if the cavity is not sufficiently deep a small amount of bark is excavated. The cavity is then lined with silk and the larva spins a cover over the entrance. After this is accomplished the larva contracts somewhat in size and is usually about 4 mm. long during the winter and somewhat thicker than when it is active. The exposed surfaces of these pockets are usually flat and are made so nicely and so closely resemble the bark that they are difficult to see. They are circular to oval in form, the shape depending on the contour of the crevice in which they are made. The length is about 4 mm.

Many of these pockets have been found on the trunks of large Carolina poplar trees (fig. 4), and it was at first thought that the bulk of the larvæ hibernate near the ground. Examinations have shown that the pockets are present high in the trees and on the

branches wherever small inequalities in the bark are present. Some webs have been taken on branches 60 feet from the ground and others

FIG. 4.—Hibernating webs or pockets of small larvæ in tree trunk. Several webs are encircled with a white line to show their location. There are other webs on this bark.

on small twigs and attached to the scars where leaves have fallen. While it is probable that most of the larvæ remain in the pockets

during the winter, a few cases have been noted where they have deserted them temporarily during the fall. On December 15, 1920, Mr. F. H. Mosher reported that a small number of the larvæ were crawling on the tree trunks at the Medford colony. The weather was warm and had been preceded by several warm days.

The hibernation pockets are very inconspicuous and it is difficult to find them even on a tree that is rather heavily infested. This being the case the insect could have been brought to this country very easily on poplar or willow trees or possibly on other species or on bits of infested bark that was mixed in packing material. The color of the webs resembles the bark so closely that they can be overlooked very easily by the most careful inspector.

Feeding of the small caterpillars is confined to the epidermis of both sides of the leaves, but if the infestation is severe most of the foliage on the trees may be denuded so that only the ribs and framework remain (fig. 3, A). As most of this feeding occurs during the first half of August, many of the leaves that are only partially eaten turn brown and drop earlier than normal. While feeding at this time of the year does not injure the trees as severely as the defoliation by the larger larvæ of the previous brood earlier in the season, it renders them unsightly and is objectionable, particularly if they are planted for ornamental purposes.

Observations in the field during 1920 indicated that feeding by the small larvæ was confined principally to different species of poplar, the Carolina, Lombardy, Balm of Gilead, and silver leaf showing the most defoliation. In the laboratory experiments willow was equally favored, but the small larvæ starved rather than feed on alder, apple, gray birch, elm, red oak, and white oak.

A few small larvæ in the laboratory survived on black-oak foliage and went into hibernation in a normal manner. This food plant may therefore be important, as it is rather common in some sections of New England.

Emergence in the spring has not been observed in this country, but the larvæ probably come out of the webs and begin feeding as soon as sufficient foliage is available. After passing through several molts they become full grown about July 1.

Full-grown larvæ (fig. 5, C, D).—Larvæ when full grown are 45 to 50 mm. long. The head is bluish black and covered with short hairs. The body is black, mottled with white markings of irregular shape. These form distinct subdorsal lines on each segment of the body and are enlarged into an additional row of somewhat square white blotches on the dorsum of each segment. The latter are characteristic of this species, make it conspicuous, and enable it to be readily recognizable. The rows of tubercles are brown, and provided with many spines and hairs that are slightly lighter in color.

After feeding is completed the larvæ seek shelter and spin loose cocoons. Many of these are made by drawing together the edges of

leaves on the trees. Cocoons are sometimes made in crevices in the bark, in rubbish near the base of trees, or on the sides of buildings.

THE PUPÆ.

The pupa (fig. 5, *A, B, E*).—The pupa is 20 to 25 mm. in length and 5 to 7 mm. wide at the base of the abdomen. It is shiny black, densely covered with long white silky hairs, except on the venter, where the hairs are scarce. The pupa can easily be seen within the cocoon. Pupation was at the maximum by July 6. The time spent in the pupal stage averages nine days.

The first moth was found July 2 and for the next two weeks the number increased.

EUROPEAN RECORDS.

This species is common in Europe and is mentioned briefly in the writings of many European entomologists. It is reported as common in England and Ireland and throughout Europe, its range extending from Spain to Eastern Asia and as far north as Norway, and it is said to be present in the Orient. One authority states that it occurs from Lapland to middle Italy and from England to Peking. A number of different races have been noted by collectors and are distinguished by variations in the coloration of the wings.

When abundant the moths are said to fly in swarms and to migrate long distances. The larvæ feed chiefly on poplar and willow, but one report states that oak foliage is eaten in England.

Usually the insect is controlled by parasites and natural enemies and is not considered as a pest of first rank.

Some authorities state that the eggs ordinarily do not hatch until spring, but occasionally hatching takes place in July or August if the weather is hot, and the small larvæ hibernate during the winter.

DISTRIBUTION IN THE UNITED STATES.¹

Scouting work to determine the extent to which the insect has spread in the United States was begun about the middle of July. As it was supposed that the infestation was local and extended for only a short distance around the area that was known to be badly infested, directions were given the men to examine poplars and willows and cover the immediate surroundings of the colony and gradually increase the circle if more infested trees were found. Special instructions were given to make careful search for the large larvæ or pupæ, as the finding of these would indicate that the insect had been present in this locality during the summer of 1919. So many infested trees were found that a new plan of scouting was adopted after the first week, the men being instructed to work in the cities or towns nearest the infested center and to move out to the

¹ In July, 1920, a small colony of this insect was discovered by Mr. J. D. Tothill, of the Entomological Branch, Dominion of Canada, at New Westminster, a suburb of Vancouver, British Columbia.

FIG. 5.—The satin moth: *a*, pupa, ventral view; *b*, pupa, lateral view; *c*, two full-grown larvae on bark (a gipsy moth larva is shown on each side of photograph in crevices of bark); *d*, full-grown larva; *e*, leaf cut away to show hairy pupa in cocoon (larval molt skin shown above pupa). *a*, *b*, *d*, *e*, enlarged; *c*, reduced.

next town as soon as infestation was found. This plan was followed until the scouting was completed. Most of the work north and west of Boston, with the exception of some towns in the Cape Ann region, was done by scouts from the Bureau of Entomology, while the region above mentioned and a number of towns south of Boston were scouted by regular assistants of the Massachusetts State forester's office. A number of town and city gipsy-moth superintendents found and re-

FIG. 6.—Map of territory infested with the satin moth.

ported the moth from their municipalities, and this helped materially in securing prompt information on the spread of the insect.

As a result of this work the insect is now known to occur over an area of 642 square miles, including 60 towns in Massachusetts and 4 in New Hampshire. Large larvæ or pupæ were found in many of the towns indicated on the map (fig. 6) as discovered infested in 1920, which shows that they were infested the previous year; in fact, 51 of the 64 towns were so infested.

Although no infestation was found in a few towns that are surrounded by infested towns, this does not indicate that the insect is not present there. Scouting was done in them rather late to secure the best results, and in some of them poplar and willow trees are very scarce.

As is the case with most introduced insects in this region, the trend of spread has been toward the north and northeast. This is undoubtedly due to the direction of the prevailing wind at the time the moths are flying.

AGE OF THE COLONY.

The remains of the egg clusters of the satin moth do not adhere to the trees very long after hatching takes place. For this reason it is very difficult to secure information of value relative to the age of the infestations found.

The worst infestation was in the area along the parkway at the Medford-Malden line, and there is no doubt that the insect has been in this locality, probably in small numbers, for several years. Information from persons residing in this section does not throw much light on the subject, as few have been able to distinguish this insect from the gipsy moth. The latter has occurred in sufficient numbers in this locality during some years to cause much annoyance and complaint. Several men who work on the parkway state that the insect was present in considerable numbers in this particular locality in 1919, and that it was probably there before that time. Mr. C. V. Blackburn took a few moths at electric lights in Stoneham in the summer of 1919, and he states that they were rather common at the same lights in 1920. In Watertown a single Lombardy poplar was found badly infested by the local moth superintendent, Mr. Van D. Horton, in July, 1920, and Mr. Horton states that the same species was present the previous year, but in less numbers.

A rather bad infestation was found in Cambridge, and Mr. Dugan, who had pruned and cared for the trees in 1918, states that the satin moth was present at that time, although he supposed that it was a native insect. It is probable that the insect has been in this country for several years and has only become abundant enough to spread very rapidly during the past two or three years.

While it is impossible to determine the original source of the infestation, it is quite probable that the insect was brought into this country during the dormant season in crevices of bark on live or dead trees, and bits of infested bark that might be mixed in packing material could easily furnish a means of transporting the insect. As previously stated, the hibernating webs of the small larvæ concealed in the crevices of bark are so inconspicuous as to pass by the most careful inspection unnoticed.

NATURAL ENEMIES.

The European publications indicate that the satin moth is extensively attacked by parasites. It is fortunate, therefore, that some of the foreign parasites of the gipsy moth are already well established in the infested area in New England.

Some of the first field observations showed that the imported Calosoma beetle (*Calosoma sycophanta* L.), which is one of the valuable insect enemies of the gipsy moth, was attacking the larvæ and pupæ of the satin moth. Both the adults and larvæ of the beetles were doing valiant service.

A few days later heavy parasitism of the large larvæ of the satin moth by *Compsilura concinnata* Meigen, another imported gipsy moth enemy, was noted. A number of the records secured indicated that it was causing higher mortality than Calosoma. Both of these beneficial insects are abundant in the central area infested by the gipsy moth, and Calosoma was found actively at work in some of the small infestations in other towns.

A small hymenopterous parasite has been reared from the eggs of *Stilpnotia salicis*. It has been determined as *Telenomus californicus* Ashm. by Mr. R. M. Fouts, of the Bureau of Entomology.

The prospect of control of this insect by parasites is encouraging, but it may be necessary to bring in from Europe some of its enemies that do not exist here at present.

REMEDIES.

Time has not permitted experiments to be conducted to determine the most effective remedies. The larvæ were so nearly full-grown at the time they were first found that spraying did not prove effectual. Later, after the eggs began to hatch, the trees on the Parkway were sprayed with arsenate of lead and a number of trees on private grounds were similarly treated. This spraying was partially effective, and on some of the trees feeding by the small larvæ was greatly reduced. The leaves of poplar trees do not hold spray material as well as most foliage, hence special care in treatment and the addition of a "sticker," such as soft soap, is advisable.

Application of creosote to the egg clusters will destroy the eggs, but it is an expensive method on account of the labor involved and is only partially effective, because many egg clusters are deposited on small branches and on the leaves and these can not be satisfactorily treated.

It is impractical to require workmen to do extensive climbing in poplar trees, as the brittle nature of the wood, and in this region the results of the work of borers, particularly the leopard moth (*Zeuzera pyrina* Fab.), render such work hazardous.

It was hoped that spraying with a contact insecticide while the trees were dormant would destroy the hibernating larvæ, but as they

make many of their webs on the twigs and in the tops of the trees, this method appears to be impracticable.

In all probability spring spraying will prove satisfactory, although no opportunity has been presented to test this method.

With our present knowledge of the insect, the following treatment seems advisable for the season of 1921:

Spray poplars and willows as soon as they are in full leaf with arsenate of lead at the rate of 10 pounds to 100 gallons of water, using soft soap for a "sticker."

If the infestation is severe, it may be necessary to repeat the operation by the middle of June.

If egg clusters are abundant on the trees in July, spray again with the same material about August 1.

If these suggestions are followed and the amount of spraying is governed by the density of infestation, satisfactory results should be secured.

The experience of a full year's work on this insect will probably result in a modification of these recommendations.

PROBABLE IMPORTANCE OF THE SPECIES.

To predict the ultimate importance of a newly introduced insect is rather hazardous. If the feeding is confined to the poplars and willows the damage will be greatly restricted. While these trees are not considered of prime economic importance, there are certain areas where they grow satisfactorily that will not support more useful species. They are also effective for ornamental planting in certain situations and are valuable for this purpose. Should the species change its menu to oak or other trees that are useful and common in this country, the status of the problem will be greatly changed. Another season will doubtless give the necessary opportunity to determine the destructive possibilities of this insect.

In the meantime, local moth superintendents, tree wardens, and others who are engaged in the protection of trees from insect pests should make sure whether or not the insect is present in the territory that comes under their supervision and, if so, apply the spraying program suggested.

The danger of the shipment of this insect to uninfested territory is considerable. As it is practically impossible to guard against this possibility by inspecting trees during the dormant season, special efforts should be made to examine the favored food plants of the insect during July and August to determine whether the insect is present. While this applies to the nurseries within the infested area, it is necessary that the work be done in the areas surrounding them if the danger of spread on shipments is to be eliminated. In cases where infestation is found the treatment recommended should be applied immediately.

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