45th Report, 1945
CONNECTICUT STATE ENTOMOLOGIST

Bulletin 501 August, 1946

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To the Director and Board of Control
Connecticut Agricultural Experiment Station:

I have the honor to transmit, herewith, the forty-fifth report of the State Entomologist for the year ending October 31, 1945.

Respectfully submitted,

ROGER B. FRIEND,
State and Station Entomologist

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CONNECTICUT STATE ENTOMOLOGIST

FORTY-FIFTH REPORT

1945

R. B. Friend

WORK OF THE DEPARTMENT

The most conspicuous trend in economic entomology in this country during the past few years has been the intense interest in insecticides. This was stimulated by the necessity for the better protection of military personnel from pests which transmit disease to man, and for the better control of insects which attack agricultural crops, livestock, forests and manufactured products. The insecticidal properties of a number of chemical compounds have been determined and better methods of applying them have been developed. The work of the Department, as far as the research phases are concerned, has followed this trend to a certain extent and our insecticidal research has received more emphasis than in previous years. Particular attention has been devoted to studies of adhesives for spray mixtures used in the orchard, the efficiency of insecticidal dusts used for the protection of field and truck crops, the relation of chemical composition to toxicity, the durability of DDT residues, and the development of apparatus for distributing concentrated sprays.

In addition to this increase in insecticidal research mentioned above, we have continued to study several entomological problems of importance to Connecticut agriculture and forestry. Among orchard pests, the Oriental fruit moth, the apple maggot, the Japanese beetle, Comstock's mealybug and the codling moth have received particular attention. As regards the pests of field crops, certain studies of the control of the European corn borer, potato pests, and wireworms have been carried out. The eastern field wireworm is the worst insect pest of potatoes in this State and often severely injures young tobacco plants.

Scarabaeid beetle larvae are particularly injurious to plants by virtue of their destruction of the root system. The Japanese beetle is the most notorious member of this family. Larvae of this insect react quite definitely to temperature gradients, and the effect of temperature on the toxicity of lead arsenate applied in the soil to Japanese beetle grubs has been investigated. One of the most significant developments in biological control in recent years has been the utilization of bacteria to suppress populations of Japanese beetle grubs. The biological aspects of the relation of these bacteria to the grubs have been studied in detail.

Some attention has been devoted to a study of pests of forest and ornamental trees. One of the most interesting problems involved is the nature of injury caused by insects. In this field a rather detailed study of the spruce gall aphid on Norway spruce is being carried out.

Boring insects are sometimes very injurious to ornamental trees, both in the nursery and after setting out, and an attempt has been made to develop control measures for certain of these pests. Another pest of ornamentals, Comstock's mealybug, is quite injurious to yew (Taxus), and the control of this insect has been worked out.

The honeybee is a useful insect whose value far exceeds the returns gained by selling two of its products—honey and beeswax. As a pollinator of agricultural plants, it is indispensable. One of the greatest hazards of beekeeping is the disease called American foul brood. The control of this by sulfathiazole was first reported by Haseman of the Missouri Agricultural Experiment Station and was tried here last year with considerable success. If further investigations support the results attained to date, we should have at hand a means of controlling this disease without completely destroying the diseased colony as is done at the present time. Another hazard in apiculture is the poisoning of bees by insecticides used to control pests. This problem, which under certain conditions may be very serious, is being investigated.

For some years the Department has been responsible for a series of bulletins published by the Connecticut Geological and Natural History Survey under the general title "Guide to the Insects of Connecticut". Bulletin No. 68, dealing with the mosquitoes of Connecticut, and written by Professor Robert Matheson of Cornell University, was published this year. Other manuscripts dealing with the Diptera are at hand and will be published as soon as possible.

The Department handles a great deal of correspondence regarding insect pests and other small injurious animals. During the year 394 specimens received by mail were identified and the correspondents informed of their injuriousness and methods by which they may be controlled. Tables 1 and 2 give a general summary of this work. It should be noted that the predominance of certain species received at this office does not reflect by any means their importance to the welfare of the State.

Table 1. Summary of Specimens Received, 1945

	Number of samples received
Pests of the household and stored grain	200
Forest and shade tree pests	63
Flower garden and greenhouse pests	20
Pests of shrubs and vines	18
Field and vegetable crop pests	16
Fruit pests	12
Soil and grassland inhabiting pests	12
Timber and wood products pests	12
Insects annoying to man and domestic animals	6
Parasitic and predaceous insects	3
Miscellaneous	32
	394

TABLE 2. INSECTS RECEIVED FIVE OR MORE TIMES, 1945

	Times received
Elm leaf beetle, *Galerucella luteola* Mull.	55
Black carpet beetle, *Attagenus piceus* Oliv.	12
Termite, *Reticulitermes flavipes* Koll.	12
Pavement ant, *Tetramorium caespitum* Linn.	12
Carpenter ant, *Camponotus herculeanus pennsylvanicus* DeG.	10
Euonymus scale, *Chionaspis euonymi* Comst.	9
Ants (miscellaneous)	8
Indian meal moth, *Plodia interpunctella* Hubn.	8
Orange-striped oak worm, *Anisota senatoria* S. & A.	5
Privet thrips, *Dendrothrips ornatus* Jab.	5

The members of the Department have published several papers during the year on various aspects of their work. A list of these are printed on pages 115 and 116. Inasmuch as the author's name appears on each contribution to this Report, the articles published here are not included in the list.

In addition to this general research program, certain inspection and control operations are carried out under the direction of this office. The inspection of nurseries and apiaries, and such inspection work as is necessary to the enforcement of Japanese beetle and European corn borer quarantines were carried out as usual. The three control operations that concern gypsy moth, Dutch elm disease and the Oriental fruit moth were also carried out in the usual manner.

Mr. Philip P. Wallace, a member of the Experiment Station staff since 1934, resigned July 31, 1945, to take a position with the Ensign Bickford Company of Simsbury, Connecticut. While employed at this Station, Mr. Wallace was engaged in Dutch elm disease control work, research on bark beetles, borers, and other pests of ornamental trees and shrubs, and a study of certain methods of applying DDT. He made many valued contributions to our knowledge of the biology and control of injurious insects.

Mr. W. H. Kelsey, employed as an apiary inspector since 1935, resigned effective January 1, 1946. Mr. Kelsey discharged his duties faithfully and efficiently at all times, a staff member whose loyalty never wavered and whose integrity was never questioned. We wish him well.

PREVALENCE OF INSECT PESTS

The most interesting insect of the year, from the entomological viewpoint, was the periodical cicada (*Magicada septendecim* L.) Brood II of this insect appeared on schedule 17 years after its last appearance in the State and in about the same places, that is, a group of towns extending from East Haven, Branford and Guilford on the Sound north to Farmington, West Hartford and Avon (Figure 1). The adults (Figure 2) were first noticed near New Haven on May 22 and continued to be present about six weeks. They declined in numbers rapidly after July 1, and the last one observed was seen July 9. Egg deposition became general in North Branford on June 18; and severe injury to apple, peach, elm, oak, maple, birch, sassafras, spicebush, and other trees and shrubs became quite prevalent (Figure 3), particularly in the region from North Branford to Middletown. The injury to the trees, at least as far as the parts above ground are concerned, is due to the egg-laying habits of the females which slit the twigs with the ovipositor in order to deposit eggs therein. This weakens the twigs and they are easily broken (Figure 4), those as large as one-half inch in diameter being affected. Injury to young fruit trees is particularly serious. Most of the information on the 1945 prevalence of cicada was obtained by Mr. B. W. McFarland of this office.

Many other insects which have been injurious to orchards in times past were more or less prevalent during the year. The Japanese beetle (*Popillia japonica* Newm.) increased in abundance in some parts of the State. The Oriental fruit moth (*Grapholitha molesta* Busck) was more numerous than in 1944, and much injury to fruit occurred in some orchards. The European apple sawfly (*Hoplocampa testudinea* Klug) was not as abundant as in 1944 and no great amount of damage occurred. Comstock's mealybug (*Pseudococcus comstocki* Kuw.), which has been at times a pest of apples and pears, was also less injurious than last year. The codling moth (*Carpocapsa pomonella* L.) caused somewhat more damage than in previous years, the population building up after July 1. We have by no means the intensity of infestation of this pest that occurs in apple orchards in other parts of the country. The apple maggot (*Rhagoletis pomonella* Walsh), which appears to be always with us, was quite injurious, and the flies occurred in the orchards until harvest in some cases. This delayed flight of adults made control operations somewhat complicated. The plum curculio (*Conotrachelus nenuphar* Herbst) and plant bugs (*Lygus* spp.) were severely injurious to peaches in several orchards. Many unsprayed apple orchards in New Haven and Middlesex counties were stripped of foliage in June by the fall cankerworms (*Alsophila pometaria* Harr.)

One of our most serious pests of field and truck crops continues to be the European corn borer. Most of its injuriousness is confined to corn. Dr. Vance of the Federal Bureau of Entomology and Plant

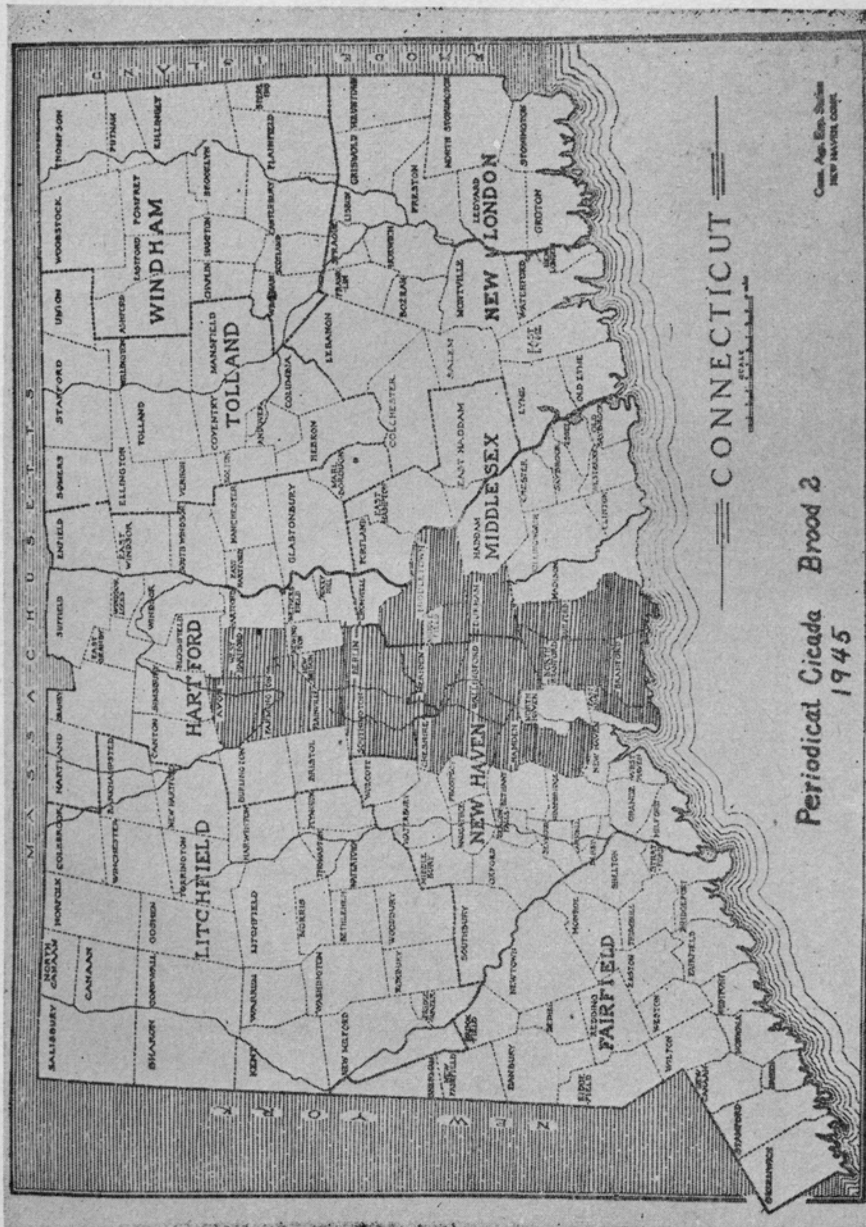

Figure 1. Distribution of the periodical cicada in 1945.

Figure 2. Adults of the periodical cicada on dogwood.

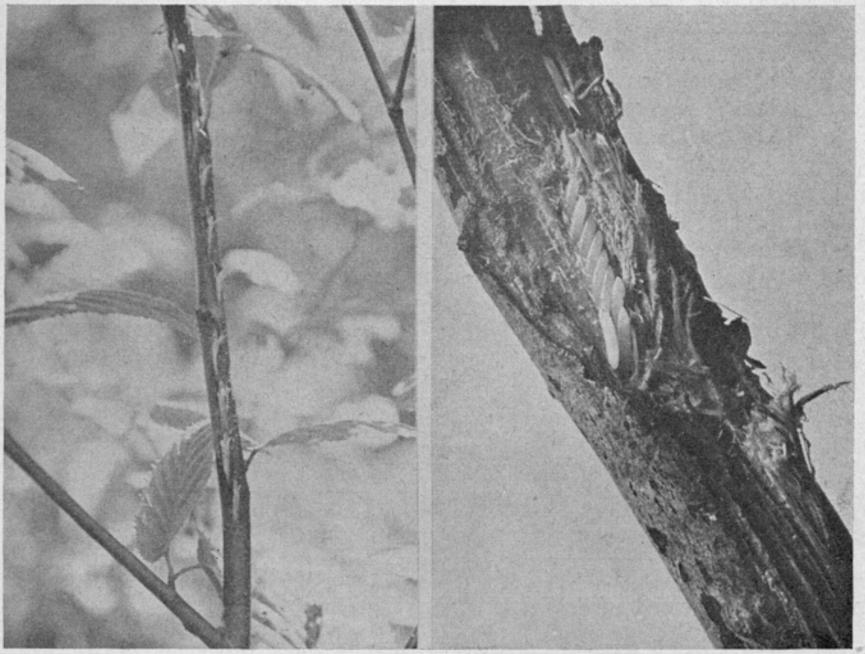

Figure 3. Left: oviposition scars of the periodical cicada on elm.
Right: eggs of periodical cicada in apple twig. (X 3).

Figure 4. Left: cicada injury to small apple tree.
Right: cicada injury to small elm tree.

Quarantine makes an annual survey of corn borer damage throughout the infested area in the United States. The degree of damage is estimated on the basis of the number of borers found per plant. According to Vance, the fall infestation in 1945 was fairly heavy in places, New Haven County having one of the highest populations in the East, 389 borers per 100 plants. Early sweet corn was much less injured than in 1944, the average infestation being two borers per plant. In all eight Connecticut counties the fall infestation averaged 145 borers per 100 plants, which is not considered heavy. In five counties for which comparable data for previous years are available, the fall infestation was 162.6 borers per 100 plants in 1944 and 179.2 in 1945, not significantly different. Vance's data are summarized in Tables 3 and 4 below:

TABLE 3. CORN BORER DAMAGE, 1945

	Entire infested area in U. S.			Connecticut	
	Acres	Crop value	Crop loss	Crop value	Crop loss
Grain corn	15,968,983	$1,141,649,989	$32,846,459 (89.3%)	$541,334	$27,924 (11.8%)
Sweet corn	306,702	32,498,410	3,918,106 (10.7%)	1,100,400	208,722 (88.2%)
	16,275,685	$1,174,148,399	$36,764,565	$1,641,734	$236,646

TABLE 4. CORN BORER INFESTATION IN FALL

County	Borers per 100 plants	
	1944	1945
Fairfield	177.4	108.4
Hartford	357.8	200.0
Litchfield	99.8	53.6
Middlesex	110.2	145.0
New Haven	68.0	389.0
New London		131.4
Tolland		63.2
Windham		69.4

Some pests of field and truck crops were quite prevalent. Flea beetles (*Epitrix cucumeris* Harr.) were injurious to potatoes and tomatoes in June, and the usual amount of wireworm injury to potatoes occurred. Another pest of truck crops, the cabbage maggot (*Hylemyia brassicae* Bouché) was moderately to severely abundant in southwestern Connecticut in May.

Our worst pest of forest and shade trees, the gypsy moth (*Porthetria dispar* Linn.) was not excessively abundant in Connecticut in 1945, and no extensive defoliation occurred. On the contrary, cankerworms (*Alsophila vernata* Peck) were quite abundant on shade and forest trees in May and June. The orange-striped oak worm (*Anisota senatoria* A. and S.) is quite frequently injurious in eastern Connecticut, and a rather heavy outbreak occurred in that part of the State in September. The eastern tent caterpillar (*Malacosoma americana*

Fabr.), which is sporadically abundant in various parts of the State, was quite conspicuous in southern Connecticut. The elm leaf beetle (*Galerucella luteola* Mull.) infestation was heavy in Stamford and the region surrounding that town and many trees were stripped of foliage. The fall webworm (*Hyphantria cunea* Dr.) was very abundant in eastern Connecticut during the last part of the summer. One of the most conspicuous enemies of the black locust is the locust leaf miner (*Chalepus dorsalis* Thunb.) This insect was quite abundant in certain parts of the State in July.

INSPECTION OF NURSERIES, 1945

M. P. Zappe and L. A. DeVaux

The annual inspection of nurseries as required by Section 2136 of the General Statutes began on July 2, 1945. Two temporary inspectors, F. A. Luddington and F. M. Richards, were employed during July and August. Both of them had had previous experience, as they were employed in 1944. Mr. DeVaux worked with them during July and August and Mr. Zappe was with them part of the time when other duties permitted. On September 27 all regular inspections were finished, although occasional inspections were made after this date to see that nurserymen had made a proper clean-up of their nursery pests. The strawberry plant growers had their fields inspected during the latter part of June. Most of these are located in New London County.

The nurserymen had a very busy season in 1945. Help was scarce and many orders could not be filled. Most of the larger nurseries were well cultivated and in good condition but some of the smaller ones were rather weedy and in some cases cultivation was omitted entirely. Owners of some of the small nurseries were employed in essential war industries and their nurseries were neglected. Some were not even registered nor inspected, and are therefore out of business, at least temporarily.

The usual numbers of nursery pests were found, but no serious outbreak of any particular pest was noted. Only 12 nurseries had infestations of pine leaf scale compared to 53 in 1944. This may be partly due to the fact that some of the nurseries have fewer mugho pines than formerly. They are not particularly desirable plants and are subject to a number of pests. Out of a total of 302 nurseries inspected, 135 were free from pests. Seven plant diseases were found and reported during the inspection period, but most of these were of a minor nature and were not considered serious.

Wood borers are probably the most serious insect pests of Connecticut nurseries. Those in linden and mountain ash appear to be most abundant and difficult to control. This is particularly true of trees grown in grass and weeds. Where clean cultivation is practised, there are fewer infested trees.

Of the scale insects, oystershell scale was the most abundant and was found in 66 nurseries. This scale is particularly abundant on willows, poplars, ash, lilac and older fruit stock. It rarely occurs on fruit stock less than three years old. No peach "X" disease was found in any Connecticut nursery in 1945. Peach trees in Connecticut are grown under special conditions so that they will be free from this disease. The regulations require that all chokecherries be removed within a 500-foot zone around the peach blocks. This must be done before the peach seedlings are above ground and they must be kept out of this area until the trees are finally harvested.

Dutch elm disease was found in or near seven nurseries. The diseased trees were immediately removed by the owners. Nectria canker on maples was present in 23 nurseries in 1944, but new cankers were found in only five nurseries in 1945.

TABLE 5. TEN-YEAR RECORD OF CERTAIN NURSERY PESTS

Pest	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945
European pine shoot moth	108	128	130	110	108	106	54	6	39	46
Oystershell scale	87	84	53	49	57	77	68	78	65	66
Pine blister rust	0	4	5	3	3	4	0	2	1	0
Pine leaf scale	72	60	25	50	48	46	23	10	53	12
Poplar canker	28	26	20	14	15	15	11	28	12	11
San José scale	11	8	2	1	2	7	4	10	15	15
Spruce gall aphids[1]	337	306	312	216	231	227	210	140	83	110
White pine weevil	82	101	97	93	70	61	27	28	31	37
Nurseries uninfested	26	25	32	19	33	32	126	148	123	135
Number of nurseries registered	380	377	402	399	376	356	331	318	297	302

[1] Includes both *Adelges abietis* and *A. cooleyi*.

One nurseryman received the special raspberry inspection and was granted a certificate, as no raspberry mosaic was found on any of his plants.

A total of 302 nurseries, five more than in 1944, were registered and inspected, but all have not been granted certificates as they have not completed the required clean-up of their pests. These nurseries have a total of 4,258 acres devoted to the growing of stock, approximately the same as in 1944. A classification of nurseries by size is given in Table 6.

TABLE 6. CLASSIFICATION OF NURSERIES BY AREA

Area	Number	Percentage
100 acres or more	7	2.34
50 to 99 acres	7	2.34
10 to 49 acres	39	12.77
5 to 9 acres	28	9.35
2 to 4 acres	77	25.4
1 acre or less	144	47.8
	302	100

Some of the nurserymen failed to register before July 1, 1945, and as required by Section 2137 of the General Statutes, were charged for the cost of inspection. Nineteen nurserymen paid this cost and $95.00 has been turned over to the Treasurer of the Station to be sent to the State Treasury. Nurserymen who registered late and failed to pay the cost of inspection and those who neglected to clean up their nursery pests were not issued certificates and therefore cannot legally sell their nursery stock. The cost of inspecting the nurseries, including a few additional visits to see that the pests were properly eradicated, was $1,884.66, exclusive of travelling expenses.

Other Kinds of Certificates Issued

During the year, 146 duplicate certificates were issued to Connecticut nurseries to be filed in other states. Sixty-two dealers' permits were issued to stores and individuals who sell but do not grow their own nursery stock. No inspection is required before issuing these certificates as all dealers are obliged to purchase their plants from certified nurseries. Approximately 70 lots of nursery stock and other plant material were inspected and certified for private individuals. Four hundred and five blister rust control area permits were issued. These permit the planting of currants and gooseberries where there are no timber stands of white pine.

Inspection of Imported Nursery Stock

Certain kinds of foreign nursery stock are allowed to enter the United States at designated ports of entry under permits issued by the Federal Bureau of Entomology and Plant Quarantine. These are released for transit to destination points where they are examined by State inspectors. Most of this nursery stock entering Connecticut consists of rose stocks, which are grafted by florists and are then grown for cut flowers in greenhouses. Since the beginning of the war, the importation of rose stocks has practically stopped, and florists purchase these stocks from the western states. During the past year only one shipment of rose stocks was received from England. This consisted of four cases containing 2,500 plants.

Miscellaneous plant material and seeds are also allowed entry into the United States under the same permit system as above. All this material is sent to Washington, D. C., where it is examined by Federal inspectors and, if found free from injurious insects and plant diseases, it is reshipped to its final destination. None of this material is inspected by State men. This year there was quite a lot of this material, mostly bulbs of flowering plants. Most of it was being sent by members of our Armed Forces who were in Europe.

3,649	Tulip
229	Crocus
172	Narcissus
168	Hyacinth
75	Muscari
24	Scilla
22	Fritillaria
3	Iris
12	Eranthis
67	Lillium Sp.
3	Sprecklia
4,920	Gladiolus
6,070	Orchids
100	Violets
5	Primula
1	Holly tree
1	Lilac
1	Pine tree
2	Robinsonella cuttings
13	Miscellaneous shrubs
7	Boysenberry plants
200	Korean boxwood
435	Strawberry plants
30	Raspberry plants
2	Grape vines
6	Currant bushes
2	Apple trees
1	Pear tree
2	pounds of tree seeds

QUARANTINE ENFORCEMENT AND MISCELLANEOUS INSPECTIONS, 1945

M. P. Zappe and L. A. DeVaux

Many states have quarantines against various pests in order to protect themselves from damage these might cause if they were introduced from infested states. This, of course, hinders the free movement of plants and plant material. Nurserymen and others who do considerable shipping of this type of material are more or less familiar with the requirements of other states. The average person knows very little about such matters and only hears of them when he or she tries to ship plants from Connecticut to other parts of the country. The United States Postal Department and transportation companies know that it is illegal to accept plants and plant material for shipment unless accompanied by a valid certificate of inspection. We are often called upon to make inspections and furnish certification for such shipments. In some cases we are obliged to refuse certification because the shipment does not comply with the requirements of the state to which it is consigned. Fortunately, most of the requirements of nearby states are such that we can certify the materials, but it is almost impossible to ship certain plants, fruit, etc., into some of the midwestern and western states.

The European corn borer has now spread to such an extent that there are only 21 states that have quarantines of their own preventing importation of susceptible plants unless properly inspected and certified. Of the plants affected by this quarantine, perennials of various kinds and shelled sweet corn are the ones most commonly shipped. A total of 455 European corn borer quarantine inspection tags was issued to certify shipments to these states and Canada. Most of this material was shelled corn being sent to Canada.

The Oriental fruit moth quarantine prevents movement of fruit, used fruit containers and fruit trees. There are five states that still maintain quarantines because of this pest. This material can be shipped, but it must be fumigated under supervision in an approved fumigation chamber. The cost of the apparatus is so high that no fruit or fruit trees have been treated for shipment from Connecticut into states having such regulations.

Since the establishment of the Japanese beetle and gypsy moth quarantines in Connecticut, this Department has cooperated with the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture in their administration. The State is divided into two sections, using the gypsy moth quarantine line as a boundary. The section of the State within the gypsy moth quarantined area, which includes Hartford, Middlesex, New London, Tolland, Windham counties, and some towns in northern and eastern Litchfield and eastern New Haven counties, is under the supervision of Mr. H. N. Bartley who is in charge of the federal Japanese beetle and gypsy moth office at Waltham, Massachusetts. His inspectors make the necessary inspections to comply with the Japanese beetle quarantine, and the balance of New Haven and Litchfield counties outside of the gypsy moth quarantined area and the towns of Branford and North Haven in the gypsy moth quarantined area are under the supervision of Mr. M. P. Zappe who is in charge of the New Haven office.

Japanese Beetle

The Japanese beetle quarantine enforcement activities consist of seasonal scouting of certain nursery and greenhouse properties for classification purposes, the inspection and certification of all articles included in the quarantine regulations and other tasks necessary to the operation of the quarantine.

Scouting for adult Japanese beetles has been conducted yearly to determine whether or not beetles were present on classified properties. Because of the decrease in the number of classified areas to be scouted, the district inspectors have performed the scouting activities. Only two certified greenhouses were scouted in the State during the 1945 season. This work was performed by Mr. W. J. Ahearn and Mr. J. F. McDevitt, each having one greenhouse to scout in his area. They began scouting on July 11 and finished September 10, 1945, having examined each greenhouse three times. No beetles were found in either case. There is only one other firm classified in the state, but it does not require scouting as it conducts a mail order business and has neither growing field nor greenhouses.

Inspection and Certification

The total number of plants inspected and certified for shipment to other states and foreign countries was 644,864. The number and kinds of certificates issued are shown in the following table:

TABLE 7. NUMBER OF CERTIFICATES ISSUED, 1945

Kind	Farm products	Cut flowers	Nursery and ornamental stock	Sand soil	Manure	Total
"A"[1]	0	0	4,302	1	0	4,303
"B"[2]	0	0	53	0	0	53
Total	0	0	4,355	1	0	4,356

[1] Used in shipments from nurserymen to customers.
[2] Used between classified nurserymen for carload shipments.

No inspections of farm products and cut flowers were made because no towns in Connecticut are within the area requiring such inspection and certification.

Gypsy Moth

The gypsy moth work consists of the inspection and certification of all materials included in the gypsy moth quarantine regulations, occasional scouting of certain areas in order to issue the necessary certificates, and other tasks necessary to the operation of the quarantine.

The total number of plants inspected and certified for shipment to points outside of the quarantined area was 4,084,981. Forest products inspected and certified totalled 153,426 pieces, 321 cords, 1,722,-720 board feet, 1,955 reels and 6,120 bundles. Stone and quarry products amounted to 2,965 tons and 67 pieces. Evergreen products totalled 3,346 bales, 8,981 pieces and 1,135 boxes. The number and kinds of certificates issued are shown in the table below:

TABLE 8. NUMBER OF CERTIFICATES ISSUED, 1945

Kind	Nursery stock	Forest products	Stone and quarry products	Evergreen products	Total
"A"[1]	67,688	554	30	1,741	70,013
"B"[1]	1,387	1,753	83	163	3,386
Total	69,075	2,307	113	1,904	73,399

[1] See footnotes to Table 7.

Miscellaneous

We are also called upon to certify miscellaneous seed shipments to foreign countries as required by the various foreign regulations. Most of these shipments are consigned to South and Central America and Canada with an occasional shipment now and then to European and other countries. During the year 1945, 641 such certificates were used, covering 326 shipments of seeds to South and Central America, Africa and Ireland, and 144 certificates because of the European corn borer were used, covering 72 shipments of seed corn to Canada.

INSPECTION OF APIARIES, 1945

M. P. Zappe

During the inspection period of 1945 there was no change in personnel nor in the areas covered by each inspector. Mr. Elbra Baker of Brooklyn works in Tolland, Windham and New London counties. Mr. Roy Stadel of Southington makes inspections in Fairfield, New Haven and Middlesex counties and Mr. W. H. Kelsey takes care of Litchfield and Hartford counties.

At the end of the year Mr. Kelsey resigned due to advanced years and ill health. Mr. Kelsey has been in the service for 11 years, working mostly in the four northern counties. When a third inspector was appointed, the inspection areas were reassigned and Mr. Kelsey had Litchfield and Hartford counties. He has been very faithful and, largely through his efficient work, American foul brood has gradually decreased in his counties. The beekeepers in these counties will miss him as he was always ready to advise them about their bee problems and he was particularly helpful to the beginners in beekeeping. He was President of the Connecticut Beekeepers' Association in 1945 and was re-elected to serve them again in 1946.

Winter mortality accounted for 21.6 per cent of the bees during the winter of 1944-45. This was very much higher than the preceding winter when winter mortality was only 5.44 per cent. There were several reasons for this mortality but, according to inspection reports, it was largely due to starvation. Much of it occurred in the spring and could probably have been prevented by feeding. While the State average was 21.6 per cent, in some counties it was much higher than this figure. Windham County, where 32 per cent of the bees died, was highest, while in Litchfield County it was only 17 per cent.

This season there were 2,589 apiaries inspected in the State, an increase of 138 over 1944, with a total of 13,353 colonies, an increase of 993 colonies from 1944. The average number of colonies per apiary in 1945 was 5.15 as against 5.04 in 1944.

There was a decrease in the amount of foul brood throughout the State. In 1944 it was 3 per cent of all colonies and in 1945 it was found in only 2.23 per cent. Fairfield County still continues to have the greatest amount of American foul brood with New Haven County second. Windham County has the least amount of foul brood but the greatest amount of winter mortality. There was a slight decrease of disease in nearly every county. Most of the diseased colonies of bees were destroyed by burning, either by the inspectors or the owners. A few cases of American foul brood were treated experimentally with sulfathiazole with rather promising results. This will be continued next year on a larger scale. Eventually many colonies of bees may be saved by this treatment, but it is too early to recommend it for general use. One case of European foul brood was found in the town of Orange and one case of sacbrood in Woodbury.

Table 9. Thirty-Six Year Record of Apiary Inspection

Year	Number apiaries	Number colonies	Average no. colonies per apiary	Average cost of inspection: Per apiary	Average cost of inspection: Per colony
1910	208	1,595	7.6	$2.40	$.28
1911	162	1,571	9.7	1.99	.21
1912	153	1,431	9.3	1.96	.21
1913	189	1,500	7.9	1.63	.21
1914	463	3,882	8.38	1.62	.19
1915	494	4,241	8.58	1.51	.175
1916	467	3,898	8.34	1.61	.19
1917	473	4,506	9.52	1.58	.166
1918	395	3,047	7.8	1.97	.25
1919	723	6,070	11.2	2.45	.29
1920	762	4,797	6.5	2.565	.41
1921	751	6,972	9.2	2.638	.24
1922	797	8,007	10.04	2.60	.257
1923	725	6,802	9.38	2.55	.27
1924	953	8,929	9.4	2.42	.25
1925	766	8,257	10.7	2.45	.22
1926	814	7,923	9.7	2.35	.24
1927	803	8,133	10.1	2.37	.234
1928	852	8,023	9.41	2.12	.225
1929	990	9,559	9.55	2.19	.227
1930	1,059	10,335	9.76	2.01	.206
1931	1,232	10,678	8.66	1.83	.212
1932	1,397	11,459	8.2	1.60	.195
1933	1,342	10,927	8.1	1.69	.208
1934	1,429	7,128	4.98	1.40	.28
1935	1,333	8,855	6.64	1.556	.234
1936	1,438	9,278	6.45	1.429	.221
1937	1,437	10,253	7.1	1.28	.18
1938	1,609	10,705	6.7	1.18	.177
1939	1,627	8,936	5.5	1.12	.204
1940	1,719	8,552	5.0	1.33	.268
1941	2,222	10,720	4.8	1.16	.239
1942	2,354	13,777	5.85	1.18	.201
1943	2,635	14,903	5.65	1.05	.186
1944	2,451	12,360	5.04	1.29	.256
1945	2,589	13,353	5.15	1.21	.235

Table 10. Inspection of Apiaries, 1945

County	Apiaries: Inspected	Apiaries: Diseased (Am.f.b.)	Colonies: Inspected	Colonies: Diseased (Am.f.b.)	Per cent diseased	Per cent died
Fairfield	449	67	2,454	142	5.78	19.76
New Haven[1]	356	38	1,918	59	3.07	21.48
Middlesex	154	8	960	9	.93	28.43
New London	321	12	1,694	20	1.18	26.5
Litchfield[2]	334	16	1,785	35	1.96	16.91
Hartford	547	17	2,935	23	.78	17.58
Tolland	216	5	750	8	1.06	23.6
Windham	212	2	857	2	.23	31.98
	2,589	165	13,353	298	2.23	21.62

[1] 1 case of European foul brood, Town of Orange.
[2] 1 case of sacbrood, Town of Woodbury.

TABLE 11. SUMMARY OF INSPECTION

	Apiaries	Colonies
Inspected, 1945	2,589	13,353
Infected with American foulbrood	165	298
Percentage infected	6.37	2.23
Average number of colonies per apiary		5.15
Average cost of inspection	$1.21	$.235
Total cost of inspection, 1945		$3,136.86

TABLE 12. COLONIES WINTER-KILLED, 1945

County	No. of colonies
Fairfield	485
Hartford	516
Litchfield	302
Middlesex	273
New Haven	412
New London	450
Tolland	177
Windham	274
Total winter-killed	2,889

The total cost of inspection varies from year to year. As the number of apiaries and colonies increase, the cost of inspection per apiary and colony is likely to decrease slightly. This was true in 1945.

FINANCIAL STATEMENT
January 1, 1945 — December 31, 1945

Disbursements

January 1 to June 30, 1945:		
Salaries	$ 945.00	
Travel	380.65	
Miscellaneous supplies	27.16	
		$1,352.81
July 1 to December 31, 1945:		
Salaries	$1,162.50	
Travel	621.55	
		1,784.05
Total disbursements for 1945		$3,136.86

Registration of Bees

Section 2129 of the General Statutes provides that each beekeeper shall register his bees on or before October 1 of each year with the town clerk of the town in which the bees are kept, and that each town clerk on or before December 1 shall report to the State Entomologist whether or not any bees have been registered and, if so, shall send a list of names and number of colonies belonging to each registrant.

In 1945, 2,589 apiaries containing 13,353 colonies were inspected. However, only 1,781 apiaries were registered. This shows that 808 more apiaries were inspected than were registered by the town clerks. No doubt some unregistered apiaries were not inspected by the apiary inspectors who did not know of their existence. Uninspected bees may be a source of foul brood infection for other bees in the community. Every effort is being made to have all beekeepers register their bees so that they may be inspected and treated if found diseased.

GYPSY MOTH CONTROL

O. B. Cooke[1] and R. B. Friend

Gypsy moth control work was carried on with the force available the past year. Some employees of this Department were still serving in the armed forces of the country and a few members were still on leave of absence from the Department, having accepted employment with concerns engaged in war production work. Type mapping (a description of which is given in the Connecticut State Entomologist's Report, Bul. 445, year 1940) was performed in the towns of Mansfield, Somers, Vernon and Winchester. Some scouting work was performed during the winter months in areas in and around nursery plots in the towns of Cromwell, Middlefield and Rocky Hill, and in previously known heavily infested areas in the towns of Ellington, Manchester, South Windsor and Vernon. All egg masses found were destroyed with creosote.

Defoliation and Susceptible Areas

An extensive survey for defoliation caused by the gypsy moth was made during the summer months in all towns in New London, Hartford, Tolland and Windham counties and in some towns in Middlesex, New Haven and Litchfield counties. The results of this survey show that there was some defoliation in Connecticut but not to such a degree as to cause alarm. Most of the defoliation was confined to individual trees, a large number of which were located in the central northern section of the State.

If we take the observed amount of defoliation as a criterion of the abundance of this insect and, hence, of the relative degree to which the environment favors it, the estimates made in 1945 are of considerable interest. The total area defoliated in each of the three southern and in all six New England states in 1945 is given in Table 13 below. This represents the greatest amount of defoliation in the history of the gypsy moth in this country. The defoliation in Connecticut was remarkably light and of no great economic significance. The distribution of the defoliated areas may be of some significance in relation to those parts of southern New England where outbreaks

[1] Major O. B. Cooke has been Deputy in Charge of Gypsy Moth Control work since November 16, 1945, when he returned to State employ from the United States Army.

TABLE 13. DEFOLIATION CAUSED BY THE GYPSY MOTH IN NEW ENGLAND IN 1945

	Acres defoliated				
	25%	50%	75%	100%	Total
Massachusetts[1]	102,695	104,350	92,474	157,313	456,832
Rhode Island	280	200	350	450	1,280
Connecticut[1]	5	4	2	5	16
All New England	298,692	225,566	132,470	164,748	821,487

[1] The total area of Massachusetts is 8,029 square miles, that of Connecticut is 4,820 square miles.

of the insect are likely to occur. A belt of towns extending from Dartmouth in southeastern Massachusetts northward through Bristol County and Norfolk County, thence westward through Worcester County into Hampshire and Franklin counties suffered most. In each of these towns the trees on 500 or more acres were completely defoliated. Relatively little defoliation occurred in those towns in Massachusetts situated along the northern border of Connecticut.

The above mentioned Massachusetts towns where the gypsy moth outbreak was so intense, with the addition of extensive areas in Plymouth and Barnstable counties (not so seriously affected in 1945), represent a general area highly susceptible to gypsy moth attack. Just why the insect is not more abundant in Connecticut is not quite clear. Unpublished work of Bess of the federal Bureau of Entomology and Plant Quarantine indicates that the nature of the site, rather than the species of trees (in regard to food plants of the insect) present, may well be of great significance in the relation to the effect of the environment on gypsy moth abundance. These site factors which are correlated with a high mortality of larvae appear to operate strongly in this State.

This favorable condition, as indicated by the absence of extensive outbreak areas, may operate through much of Connecticut. The scattered distribution of defoliated trees is shown by an analysis of the defoliation in 1945. In 30 towns extending south to Rocky Hill, the trees on one-tenth of an acre or more were stripped of foliage. In only four towns did defoliation extend over one acre in toto. The data for these four is given in Table 14 below. The gypsy moth has been present in Connecticut about 40 years and has been found west of the Connecticut River about 24 years. In that period only two extensive outbreaks have occurred, one involving about 30 acres at Groton in 1933 and one involving about 1,500 acres in Granby and vicinity in 1938 and 1939. It may be premature to rely on this record

TABLE 14. GYPSY MOTH DEFOLIATION IN CONNECTICUT, 1945
Towns with 1 acre or more defoliated

Town	Number of acres defoliated				
	25%	50%	75%	100%	Total
Burlington	0	0.1	0.25	1.4	1.75
Granby	1.5	0	0.2	2.1	3.8
Hartland	0.8	1.0	0	0	1.8
New Hartford	0.4	0	0.8	0.4	1.6

as an indication of what will happen in the future, but to date the record has been good and forms a basis for our control operations.

That part of the State most favorable to the development of gypsy moth outbreaks appears to lie in Hartford and Litchfield counties. This is based on the records of past infestations and the present status of the insect, as well as on the abundance of oak trees in the forests. The four towns listed above are in this area. At the present time an area of about 200 acres in Barkhamsted and about 70 acres in West Hartford and Farmington are heavily infested and should be treated with insecticides in 1946 to prevent severe defoliation.

In New England the federal Bureau of Entomology and Plant Quarantine reports that, in general, in spite of starvation and wilt disease in the intensely infested areas in 1945, there are more egg masses at present (fall of 1945) than there were in the fall of 1944.

Spraying

A spraying program was set up and carried to completion insofar as was possible during the spring and early summer with the equipment, men and time available. In all, 38 infested trees and areas were sprayed with mixtures containing either DDT, cryolite or arsenate of lead. The four largest infested areas, all woodland, one of five acres, one of 10 acres and one of 20 acres located in the town of Barkhamsted, and one of 24 acres located in the town of Granby, were sprayed with a helicopter that was loaned to us by the U. S. Coast Guard.

The treatments applied by the helicopter were effective in three of the four areas, as indicated by the number of old and new egg masses found in the fall of 1945 (Table 15). All areas were sprayed during the last week in May or the first three weeks in June with a solution of one pound of DDT in a mixture of one quart of xylene and three quarts of kerosene, applied at the rate of one gallon (one pound of DDT) per acre. The entire Granby area was not examined for egg

TABLE 15. GYPSY MOTH CONTROL — HELICOPTER — 1945

Area	Date sprayed	Egg masses found, fall 1945	
		1944 e.m.	1945 e.m.
Granby, 24 acres	June 19, 1945	47	164[1] 287[1]
Barkhamsted, 5 acres	May 30, 1945	156	6
Barkhamsted, 10 acres	June 19, 1945	97	5
Barkhamsted, 20 acres	June 19, 1945	498	1

[1] See text.

masses, so the figures in the table represent those found in a strip along each side of the road running through the plot. In one strip, 47 old (1944) egg masses were found and 164 new (1945). The old egg masses were not counted in the other strip. The reason for failure in this plot may lie in either the relatively high wind which blew the insecticide off the plot or inability of the pilot to locate the markers with a consequent application at the wrong place.

The helicopter has many good attributes in spraying forest trees but, in its present state of development, it does not appear to be as useful as a standard type winged plane for this purpose. The model we used (not the latest) had too small a carrying capacity, about 30 gallons being the maximum load. The biplanes used by the federal Bureau of Entomology and Plant Quarantine carried a load of 75 to 100 gallons. These were small but maneuverable and had the necessary reserve power. They were equipped with either a spinner disk dispersing apparatus or a series of nozzles on a boom. At a speed of 80 miles per hour, they could spray 16 acres a minute, applying one gallon per acre. One of these planes actually treated 625 acres in one morning. The cost, exclusive of depreciation on equipment, was about two dollars per acre. With an orthodox ground spraying apparatus, the cost, including depreciation, would be about 20 dollars per acre. A dose of one pound of DDT per acre will practically eliminate the gypsy moth from an area, and one-half pound per acre will give excellent control.

Mr. Randall Latta of the Bureau of Entomology and Plant Quarantine carried out a series of experiments with a DDT emulsion applied with a Hochberg-LaMer aerosol generator. Several large infested oaks and strips of woodland in Connecticut were treated for the control of larvae. Mr. Latta's report has not been published, so the results cannot be given here.

The federal Bureau of Entomology and Plant Quarantine, as in the past, performed extensive gypsy moth control work in the western part of Connecticut during the year. In Litchfield and New Haven counties, the Bureau sprayed 45 infested areas with 1,786 pounds of insecticides (DDT, cryolite, or arsenate of lead). A small number of burlap bands were applied to trees at infested areas in the towns of Canaan, Salisbury and Sharon.

There are factors aside from the control of pests to be considered in applying DDT over large areas, as the danger to man and domesticated animals, to wild animals other than insects and to useful insects. According to a recent press release by the United States Department of Agriculture, no case of poisoning to man or domesticated animals by DDT has been called to their attention. The effect of this insecticide on mammals is less severe than that of nicotine or lead arsenate.

As for the effect on wild animals and useful insects, the use of DDT in forested areas at the doses employed will probably not be so injurious as at first anticipated. Doses of one pound per acre or less do not seriously affect birds but may be harmful to fish. As for insects other than those the DDT is intended to kill, the comments of

Dr. C. T. Brues[1] who, at the request of the National Audubon Society, investigated the deleterious effects of DDT on an area sprayed for gypsy moth control, are interesting. Brues confined his observations to the effect on the general insect fauna on an area of about 50 acres near Athol, Mass., sprayed with 1.43 pounds of DDT per acre by the Bureau of Entomology and Plant Quarantine on June 2, 1945. Insects were collected up to September 9 in this area and in two others nearby which were infested but not sprayed. The gypsy moth was completely controlled in the sprayed area and the foliage remained normal. There was almost complete defoliation in the two unsprayed areas. Throughout the summer other insects were more abundant in the sprayed plots than in those not treated. Brues attributes this to the preservation of the normal forest environment in the former, whereas in the latter much of the canopy was removed by the leaf-eating caterpillars.

As for egg parasites, the federal Bureau collected three egg masses of the current year in a sprayed area in the Wendell Forest, Massachusetts. The eggs were fertile and were parasitized by *Anastatus bifasciatus* to the extent of 22 per cent, 30 per cent, and 32 per cent, respectively.

Survey for Infestations

For the past few years and again this year, the State gypsy moth force has assisted the federal Bureau of Entomology and Plant Quarantine in a gypsy moth sex attractant survey. During July and August, 1945, members of this Department placed and patrolled 481 traps in various locations in the following towns in Connecticut: Bridgewater, Brookfield, Middlebury, Monroe, Newtown, Oxford, Roxbury, Shelton, Southbury and Woodbury.

The federal Bureau placed traps in Sharon and New Haven. In all 12 towns, 189,324 acres were involved. The results, taken from the Annual Report for 1945 of the Division of Gypsy and Brown-tail Moths Control of the Bureau, are given in Table 16 below. Sharon is in the Barrier Zone and has been infested for a number of years. Only six moths were caught in the rest of the area. Two of these were in New Haven at the site of a previous infestation.

Between July 1, 1944 and June 30, 1945, the federal Bureau surveyed with ground crews 18 towns in Litchfield County and four towns in New Haven County, all in the Barrier Zone and all of them likely to be infested. Ninety-eight per cent of the 60,000 acres surveyed was in Litchfield County. One hundred-seventeen infestations containing over 48,000 egg masses were found. In Litchfield County 10 or more infestations were found in each of the following towns: Canaan, Cornwall, Litchfield, North Canaan, Sharon and Warren. In New Haven County no infestations were found in Middlebury and Southbury, but one infestation containing one egg mass

[1] See Annual Report for 1944, Division of Gypsy and Brown-tail Moths Control, Bureau of Entomology and Plant Quarantine, U. S. D. A.

was found in New Haven and one containing 21 egg masses was found in Wallingford. Both these last two infestations were in localities previously known to be infested. Only restricted areas were surveyed in New Haven County.

TABLE 16. TRAPPING SURVEY, CONNECTICUT, 1945

Town	Acres involved	Number of traps used	Number of traps in which moths were caught	Number of moths caught
Sharon	38,819	140	66	165
Newtown	38,664	110	2	2
Southbury	25,818	85	0	0
Oxford	23,035	62	0	0
Shelton	19,978	62	1	1
Monroe	15,200	45	0	0
Woodbury	7,781	33	1	1
Roxbury	5,842	15	0	0
Brookfield	4,250	10	0	0
Middlebury	4,160	15	0	0
Bridgewater	3,400	15	0	0
New Haven	2,377	15	1	2
Total	189,324	607	71	171

The gypsy moth was more abundant in 1945 than in the previous year, especially in the northwestern part of the State. Thanks to the federal Bureau, which carries out control operations in the Barrier Zone, the situation there is not alarming at the present time.

Hatching of Eggs

As an aid in determining the trend of the gypsy moth population within the State, egg masses are collected each year in the early spring, held outdoors until the eggs hatch, then the numbers of hatched and unhatched eggs in each mass are counted to obtain the percentage of hatch. The results obtained this year are listed below:

Number of egg masses collected	115
Number of eggs per mass	705
Number of eggs hatched per mass	412
Per cent hatched	58.5

In the New York-New England area, in general, the hatch was 65 per cent, as determined by the federal Bureau. In the vicinity of Greenfield, Mass., eggs began to hatch April 7 and, by April 19, 50 per cent of the eggs had hatched in Massachusetts, two weeks earlier than normal.

The Division of Gypsy and Brown-tail Moths Control of the federal Bureau of Entomology and Plant Quarantine cooperates with this office in control work in Connecticut. We take this opportunity to express our appreciation to R. A. Sheals, Chief of the Division, and to S. S. Crossman and H. L. Blaisdell, Assistant Chiefs.

SPREAD OF THE DUTCH ELM DISEASE IN CONNECTICUT

M. P. Zappe

The Dutch elm disease was first found in Greenwich in 1933. Since then the disease has spread to the east and north and in 1945 it was found present in each county. In the eastern part of the State it is still rather scarce, as it has only recently reached that region. In the areas where it has been present for several years it is causing considerable loss of elms. This is particularly true of Fairfield and New Haven counties. Some of the towns have consistently removed diseased trees as soon as they are found. In these towns the tree wardens make regular inspections of the elm trees. Many of the towns remove diseased trees from private property to safeguard trees on other property and on town highways. Conditions in some of the towns are very serious, as they have lost many elms.

Each diseased tree left after the bark beetles emerge is a potential source of infection for other trees. These trees are often left due to neglect, lack of funds for their removal, or shortage of available help, particularly tree climbers.

The Bureau of Entomology and Plant Quarantine no longer carries on control operations in the older infected territory. Its activity is confined to scouting for trees in the newly infected areas. This is a zone east of the Connecticut River and to within 10 or 15 miles of the Rhode Island line, part of it infected and part of it comprising a 20-mile-wide border zone. When diseased trees are found, they are reported to the State Entomologist's office and we, in turn, notify the authorities in the town where the trees are located. The exact location of the diseased tree is given and the authorities are urged to remove it without delay, pointing out the fact that, if it is left, it may result in further spread of the disease in their town.

The United States Department of Agriculture scouts reported 160 diseased elms east of the Connecticut River during 1945. Thirty-six of these were located in 16 towns where the disease was not known to be present before this year. These are as follows: Westbrook, Old Saybrook, Essex, Waterford, New London, Montville, Norwich, Lisbon, Colchester, Lebanon, Marlborough, Hebron, Windham, Chaplin, Mansfield and Somers. The conditions in East Hartford, Glastonbury and Portland are particularly bad as 18 diseased trees were reported in 1945 in East Hartford, 28 in Glastonbury and 43 in Portland. The first diseased elms were found in East Hartford and Glastonbury in 1944 and in Portland in 1942.

The European bark beetle, *Scolytus multistriatus* Marsh., the principal vector of Dutch elm disease, has been known to be present in the above area for several years. Large numbers of this beetle may account for the abnormally rapid rise of the disease in these towns. During 1943 and 1944 we attempted to trap Scolytid beetles in trap logs in the area east of the Connecticut River in order to find out if any beetles have been collected in all towns where the Dutch elm disease has appeared. We also have records of its occurrence beyond the limits of known Dutch elm disease locations. Apparently, the beetles are spreading toward the east, followed closely by the Dutch elm disease.

DUTCH ELM DISEASE IN SOUTHWESTERN CONNECTICUT

John C. Schread, Philip P. Wallace[1] and George A. Zentmyer[2]

Since 1942 a study of the development of the Dutch elm disease, *Graphium ulmi*, in the southwestern part of Connecticut has been carried on. Five one-half mile square plots were laid out in each of the following four towns in Fairfield County that year: Greenwich, Stamford, Darien and Norwalk.

During July of each year since 1942, the plots have been scouted and samples taken to determine the degree of spread of the disease in the elm trees in the plots. Table 17 gives a summary of the results of this work for the past four years. It can be seen that the number of diseased trees has varied from year to year in any single plot and from plot to plot, there being an increase in some years and a decrease in others. The plots in Stamford have shown consistently a more rapid increase in the number of diseased trees each year, especially so in plot 1. From 1942 through 1944 the increase in this town was very rapid. However, in 1945 there was a 31.85 per cent decline in the number of diseased trees found in these plots. In the five plots in Greenwich the number of diseased trees more than doubled from 1944 to 1945, but the actual number of diseased trees is not great. In the Darien plots the total number of diseased trees increased 84.37 per cent from 1944 to 1945, while in the Norwalk plots there was a 33.33 per cent decrease in diseased trees located.

Table 18 gives the total percentage of trees from *Graphium ulmi* in the five plots in each town and the number of diseased trees per square mile of all plots in their respective towns. On a basis of the number of square miles in each town, a total estimated number of diseased trees for each town has been figured and is shown in the table. This estimate is not very precise, for we do not know how many diseased trees have been removed in each town.

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[1] Now with Monsanto Chemical Co., St. Louis 4, Mo.

[2] Formerly plant pathologist, Connecticut Agricultural Experiment Station; now plant pathologist, Citrus Experiment Station, Riverside, Calif.

TABLE 17. DUTCH ELM DISEASE SUMMARY, 1942 THROUGH 1945, SHOWING THE NUMBER OF TREES DISEASED IN EACH OF 20 PLOTS OVER A PERIOD OF FOUR YEARS IN FOUR TOWNS IN CONNECTICUT

Town	Sq. miles scouted	Town area sq. miles	No. elms estimated In plot	In town	Diseased trees in plots[1] 1942	1943	1944	1945
Greenwich								
1	.24		592		5	5	3	7
2	.31		387		..	..	..	4
3	.25		194		..	..	..	1
4	.20		242		3	..	1	1
5	.15		235		3	1	2	0
Total	1.15	42.7	1,650	61,215	11	6	6	13
Stamford								
1	.27		375		9	25	111	52
2	.26		250		6	2	..	9
3	.25		379		3	11	11	23
4	.25		213		1	5	9	2
5	.25		224		0	7	4	6
Total	1.28	38.1	1,441	42,798	19	50	135	92
Darien								
1	.20		215		6	8	5	6
2	.25		217		7	5	6	4
3	.25		239		1	4	14	30
4	.27		359		5	7	5	19
5	.25		90		1	0	2	0
Total	1.22	14.9	1,120	13,664	20	24	32	59
Norwalk								
1	.22		234		1	1	..	2
2	.21		226		3	3	30	15
3	.20		613		1	4	2	0
4	.23		40		0	2	..	2
5	.18		70		5	2	4	5
Total	1.04	24.6	1,183	27,993	10	12	36	25

[1] The data in this and the following table represent trees diseased the year indicated. Trees which were recorded in previous years are *not* included.

TABLE 18. PER CENT DISEASE OF TOTAL ELMS IN PLOTS AND NUMBER OF TREES DISEASED PER SQUARE MILE OF PLOTS AND TOWNS

		Greenwich	Stamford	Darien	Norwalk
Graphium ulmi, per cent of total elms in plots	1942	.66	1.38	1.78	.84
	1943	.36	3.46	2.14	1.01
	1944	.36	9.36	2.85	3.04
	1945	.78	6.38	5.26	2.02
Graphium ulmi per square mile of plots	1942	9.6	15.0	16.0	9.6
	1943	5.2	39.0	19.7	11.5
	1944	5.2	105.4	26.2	34.6
	1945	11.3	71.8	48.3	23.0
Total estimated *Graphium ulmi* in town	1942	408	564	244	236
	1943	223	1,485	292	283
	1944	223	4,006	391	851
	1945	482	2,735	719	565

MOSQUITO CONTROL IN 1945

R. C. Botsford, Agent
State Board of Mosquito Control

Mosquito suppression work by the Board was carried on by authority of Sec. 2416 of the General Statutes as usual. Only three laborers were available, but the four foremen also cleaned ditches, dug out closed outlets, oiled certain areas and patrolled and inspected salt marshes as far as time would permit. Work was concentrated on areas known to be highly dangerous and this prevented large scale breeding. Salt marsh areas where major repairs are required to prevent flooding were omitted from this season's work. It would not be economical to reditch the damaged areas until repairs to dikes or tide gates are completed.

Funds were granted by the Legislature for certain major repairs, the status of which is outlined below.

> The new tide gate on Sybil Creek at Indian Neck, Branford, which prevents the flooding of 89 acres of salt marsh, was completed and some of the ditches were recut.
>
> Engineering plans for a new tide gate on a proposed bridge at Beach Park Road in Clinton are completed. The condition of more than 200 acres of salt marsh in poor condition can be corrected by this construction.
>
> The outlet to Rusby Meadow in Westbrook was repaired and reinforced by concrete.
>
> Repairs to Stony Creek Dike in Branford, protecting 63 acres of salt marsh, were completed.
>
> Engineering work on the construction of the Great Harbor Dike protecting 200 acres in Guilford, the Indian River Tide Gate protecting over 50 acres in Clinton, and repairs to the Farm River Tide Gate are in progress.

The condition of the Hammock River marsh of more than 100 acres north of Post Road, Route No. 1, Clinton, poorly drained, cannot be corrected until the proposed tide gate at Beach Park Road is installed.

Mosquitoes originating from fresh water areas were reported to be abundant this season. Fresh water mosquito control is considered a local problem in that the species do not migrate any great distance from their breeding places as do the salt marsh species. This Board does not include the control of fresh water species in its regular control program, but will give aid to any organized effort in the line of technical advice and field surveys as time permits. Fresh water areas are defined as any mosquito breeding places beyond the reach of normal high tides. Usually in swampy places, these may be determined by the type of vegetation.

No surveys of inland areas were made this year but several towns made use of information we had accumulated in the 1944 surveys which had been forwarded to the health officers. Among these towns were Bristol, New Britain, Plainville, Newington and East Hartford.

The abundance of mosquitoes in some localities brought forth many inquiries concerning the application of larvicides by airplane and the use of repellents. The new repellents when properly applied will keep mosquitoes away for several hours and are a great convenience at times.

Present repellents will probably never take the place of eliminating mosquitoes at their source. Larvicides and insecticides spread by airplanes over large areas are effective but, under certain conditions, as yet, too expensive for general use.

The use of DDT as an insecticide made possible the enjoyment of six outdoor concerts in the Yale Bowl last season without mosquito annoyance. Previous to treatment, mosquitoes were plentiful and were biting at the rate of about five per minute. The DDT was applied by spraying with a helicopter and also by fogging with power mist blowers. This work was experimental and carried out to test methods of application. The DDT solution was made up according to the following formula: DDT one pound, xylene one quart, kerosene three quarts.

The first spraying of the Yale Bowl was made by helicopter on July 5, including the city block and some of Edgewood Park. About 85 acres were covered and about 95 gallons of mixture used. Mosquitoes were entirely absent for about 5 days, then reappeared in small numbers, requiring re-spraying before the next concert. Sprays were applied a day or two before each of the four following concerts by power blower, covering only the inside of the Bowl and seat area and the outside of the Bowl inside of the fence, about 20 acres. The sixth and last concert was treated August 29 by helicopter, spraying the Bowl and immediate outside area.

The same DDT formula was applied by power blower to a residential area of about 14 acres in Farmington and a similar area in Wethersfield. In all cases adult mosquitoes were eliminated for a period of eight to 12 days, after which time mosquitoes gradually increased in abundance.

The work plans for next season, in addition to the patrol of the marshes and cleaning of ditches, will include the construction of two tide gates in Clinton; reconstruction of the dike and tide gate at Great Harbor, Guilford; and repairs to the Farm River tide gate in East Haven. Also, further trials will be made with DDT.

SPRAYING WITH A HELICOPTER[1]

Many types of apparatus for applying insecticides have been tested in recent years, and one of the most interesting of these is the

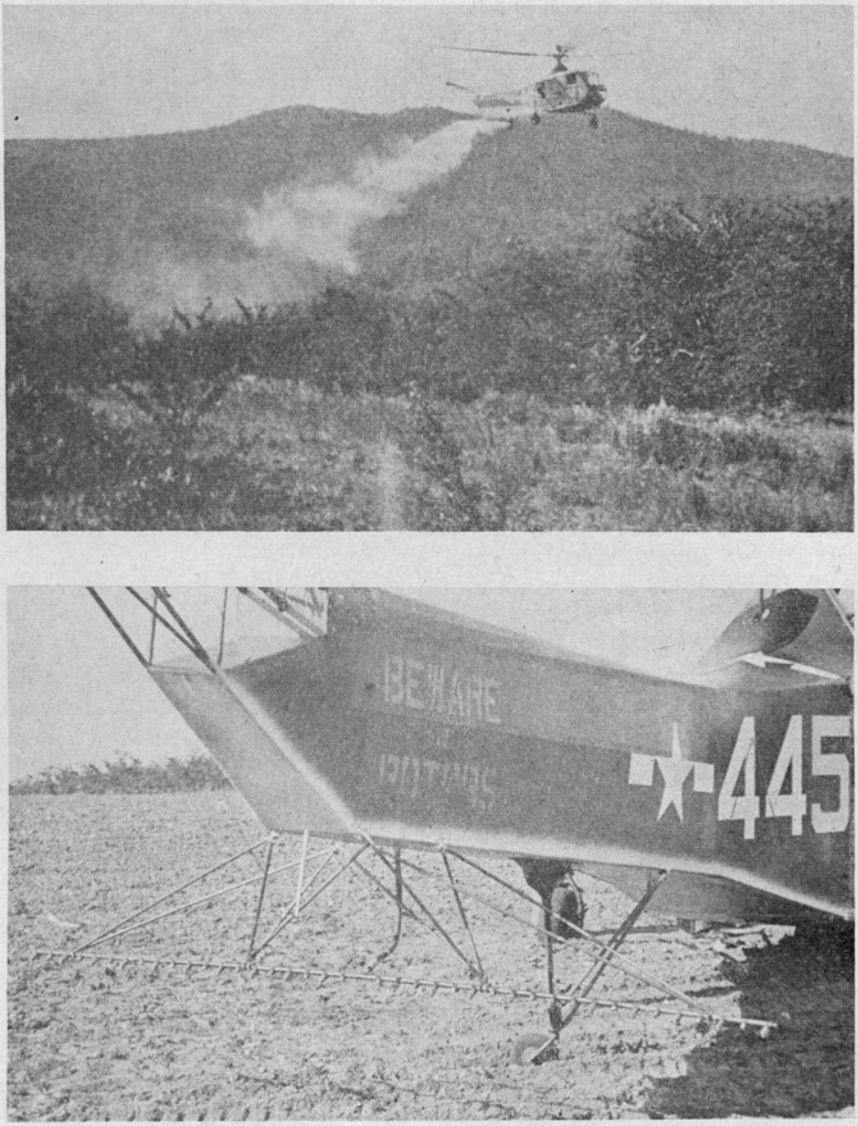

**Figure 5. Upper: Helicopter spraying an orchard at Middlefield, Conn.
Lower: Spray boom on helicopter.**

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[1] The general supervision of this work as it concerned our staff was under the direction of Mr. M. P. Zappe. Mr. Turner assisted on the potato spraying experiment; Mr. Plumb, on those connected with the European pine shoot moth and pine sawfly; Dr. Garman, on those concerned with apple maggot and 17-year locust; and Mr. Schread, on those involving Japanese beetle.

helicopter. During the summer of 1945 we were fortunately able to cooperate with the Coast Guard and the Federal Bureau of Entomology and Plant Quarantine in investigating its practicability. The Coast Guard furnished a Sikorsky model Y. R. 4 which had been converted from a trainer. It was equipped with a 30-gallon tank and a pump that would discharge 2.85 gallons of spray per minute at 75 pounds' pressure and 3.95 gallons per minute at 150 pounds' pressure. In the experiments carried out in Connecticut, 150 pounds' pressure was always used. The spray boom under the tail carried 20 ¼ TT8001 nozzles with an orifice diameter of .02 inch. The craft flew 20 to 40 feet above the trees or, in the case of field crops, above the ground, at a cruising speed of 50 to 60 miles per hour.

Most of the spraying operations were carried out early in the morning just after dawn. There is usually little or no wind at this time and thermal currents are absent. Early morning mists sometimes caused a slight delay.

The spray formula used on most plots was one pound of DDT, one quart of xylene, and kerosene to make one gallon. Variations of this were used on a few plots. The rate of application was usually one gallon per acre. Clean glass plates were placed on the ground in the plots before spraying to give an indication of spray deposit and distribution. Examination of these plots immediately after spraying showed a good deposit, even in woodland areas where there was a dense canopy of foliage. Pieces of white cotton cloth, one yard square, pegged to the ground so as to catch insects killed by the spray, gave some indication of its effectiveness.

Since the main object was to determine whether or not the helicopter showed promise as a spraying machine to apply concentrated insecticides in small amounts per acre, a number of plots, most of them five acres or more in area, having different types of insect infestation, were treated. Only a rough approximation of the effect of the insecticide was possible. Difficulties in arranging and carrying out a proper schedule of treatments were encountered, but these are inherent to any such operations.

Those who were responsible for the operations in the field deserve the highest praise. The pilot of the helicopter, Ensign David Gershowitz of the Coast Guard, carried out all assignments enthusiastically and on schedule. Undoubtedly that rabbit's foot in his pocket kept him free of trouble. Aviation Mechanic (1st Class) Roy Wagner of the Coast Guard, to whom the working parts of a helicopter are an open book, saw to it that no mechanical difficulties were encountered. Lieutenant J. S. Yuill of the Navy, an entomologist of high repute in civil life, was chief coordinator for the Navy and the Federal Bureau of Entomology and Plant Quarantine. John V. Schaffner, Jr., of the Federal Bureau of Entomology and Plant Quarantine, and members of the Station staff carried out the entomological operations.

The extent of operations is shown in the table below.

TABLE 19. HELICOPTER SPRAYING, 1945

Date		Host	Insect	Town	Acres sprayed	DDT per acre
May	22	Apple	Cankerworms	Branford	5	1 lb.
	22	Apple	Cankerworms	Branford	5	2 lbs.
	22	Apple	Cankerworms	Branford	5	½ lb.
	24	White pine	Pine bark aphis	Hamden	5	3 lbs.
	24	Oak	Cankerworms	North Haven	10	2 lbs.
	25	Oak	Cankerworms	Hamden	10	3 lbs.
	25	Oak-Maple	Cankerworms	Hamden	10	1 lb.
	25	Elm-Maple	Cankerworms	Cheshire	5	1 lb.
	29	Elm	Cankerworms Scolytus	Portland	5	2 lbs.
	29	Elm	Cankerworms Scolytus	Portland	5	4 lbs.
	29	Elm	Cankerworms Scolytus	Portland	5	8 lbs.
	30	Oak-Birch-Poplar	Gypsy moth	Barkhamsted	5	2.4 lbs.
	30	Oak	Gypsy moth	Bloomfield	1	1 lb.
	31	Apple	17-yr. cicada	Middlefield	5	3 lbs.
	31	Apple	17-yr. cicada	Middlefield	5	2 lbs.
	31	Apple	17-yr. cicada	E. Wallingford	5	3 lbs.
June	19	Woodland	Gypsy moth	Barkhamsted	10	1 lb.
	19	Woodland	Gypsy moth	Barkhamsted	20	1 lb.
	19	Woodland	Gypsy moth	Granby	24	1 lb.
	19	White Oak	Gypsy moth	North Granby	isolated trees	1 lb.
	21	Woodland and Pond	General effect	Farmington	5	1 lb.
	21	Red Pine	European pine shoot moth	Southington	5	1 lb.
	22	Red Pine	*Diprion frutetorum*	Branford	5	1 lb.
July	3	Potato	Potato insects	Cheshire	10	1 lb.
	4	Potato	Potato insects	Ellington	10	1 lb.
	4	Potato	Potato insects	Ellington	10	1 lb.
	4	Potato	Potato insects	East Windsor	10	1 lb.
	4	Potato	Potato insects	Manchester	10	1 lb.
	5	Yale Bowl	Mosquitoes	New Haven	83	1 lb.
	11	Potato	Potato insects	Cheshire	20	1 lb.
	11	Apple	Apple maggot	Meriden	5	1 lb.
	11	Birch	*Fenusa pusillus*	Cheshire	5	1 lb.
	12	Potato	Potato insects	Ellington	20	1 lb.
	12	Potato	Potato insects	Ellington	10	1 lb.
	12	Potato	Potato insects	East Windsor	10	1 lb.
	12	Potato	Potato insects	Manchester	10	1 lb.
	12	Potato	Potato insects	Ellington	8	1 lb.

TABLE 19. HELICOPTER SPRAYING, 1945—(Concluded)

Date		Host	Insect	Town	Acres sprayed	DDT per acre
August	8	Potato	Potato insects	Cheshire	20	1 lb.
	8	Apple	Apple maggot	Meriden	5	1 lb.
	13	Potato	Potato insects	Ellington	20	1 lb.
	13	Potato	Potato insects	Ellington	10	1 lb.
	13	Potato	Potato insects	East Windsor	10	1 lb.
	13	Potato	Potato insects	Ellington	10	1 lb.
	13	Woodland	Japanese beetle	Bloomfield	5	1 lb.
	28	Woodland	*Anisota senatoria*	East Lyme	5	1 lb.
	28	Woodland	*Anisota senatoria*	East Lyme	5	½ lb.
	28	Woodland	*Anisota senatoria*	East Lyme	5	¼ lb.
	29	Yale Bowl	Mosquitoes	New Haven	50	1 lb.
	31	Pine	*Diprion frutetorum*	Litchfield	6	1 lb.
	31	Pine	*Diprion frutetorum*	Litchfield	16½	½ lb.
	31	Pine	*Diprion frutetorum*	Litchfield	5	¼ lb.
	31	Pine	*Diprion frutetorum*	Litchfield	5	⅛ lb.

Cankerworms

Several plots were sprayed for the control of cankerworms, including an orchard in Branford and woodland areas in North Haven and Hamden. Various amounts of DDT were used, from one-half to three pounds per acre. Due to lack of sufficient help, it was impossible to get detailed results from all plots, but it was estimated that about 80 per cent control was obtained on plots that were sprayed with DDT at the rate of one pound per acre. In the orchard at Branford, where cankerworms were particularly abundant, counts of dead and dying larvae on cloth screens one yard square in area showed an average of about 275 per screen.

The adjacent plots of five acres each in Portland were sprayed for cankerworms and the smaller European bark beetle with 2, 4 and 8 pounds of DDT per acre. It was not possible to get any information on effect of the spraying on the above mentioned insects. Dr. S. C. Ball, Curator of Zoology at the Peabody Museum, visited the plots two weeks after spraying to determine the effect on bird life. As these plots were sprayed with comparatively heavy doses of DDT, harmful effects on bird life should be evident here, if anywhere. After examination of the plots and intermediate areas, Dr. Ball concluded that the birds were not seriously affected.

Pine Bark Aphid

A five-acre plot of white pine in the Sleeping Giant State Park in Hamden heavily infested with pine bark aphids, was sprayed on May 24. An examination of the plot later in the season disclosed that the infestation had been nearly exterminated and it was believed that the spray was effective; however, in a check plot one-fourth mile away the infestation was also reduced, probably due to natural causes. The caretaker stated that flies and mosquitoes that were usually abundant in the area were notably missing for several weeks after spraying.

Gypsy Moth

Several areas were sprayed for the control of the gypsy moth, and the results in general were excellent (see pages 28-29).

Periodical Cicada

As the periodical cicada was in the adult stage in Connecticut this summer, we had an opportunity to try DDT on this insect. At Middlefield 10 acres of orchard were sprayed with the helicopter and five acres in East Wallingford. Spraying conditions were good, and examinations were made at intervals for several days after the spraying. Apparently, the cicadas were not injured in the least by the DDT as no dead individuals were found. A number were collected after spraying and placed in insect cages where they lived for 10 days before any died.

General

An area of five acres in Farmington was sprayed with the aim of determining the effect of this dose of DDT on animal life in general. We were unable to examine the area suitably after treatment.

European Pine Shoot Moth

Spraying was carried out on a block of four to five acres of pure red pine about eight feet in height on the watershed of the Shuttle Meadow Reservoir, Southington. These trees were heavily infested with the European pine shoot moth. The moths had been emerging previous to June 21 and many females were in evidence. A count was made on July 27 of the spring-infested tips on 21 trees, and of both spring- and summer-infested tips on six trees. The spring-infested tips numbered 46.8, the summer-infested tips 102.2, per tree. Previous figures obtained for the average number of tips on a tree of a given height indicate 104 for an eight-foot tree. In arriving at this figure only the tips on the upper six feet were included. The counts made at Southington are comparable, however, since the lower two or three whorls had been removed by pruning.

The date of application was made too early, as insecticides are usually applied later in June and early in July. The DDT mixture (12.5 per cent) applied at the rate of one pound per acre obviously failed to kill the moths, nor did it exhibit any residual effect upon the newly-hatched larvae. Lack of residual effect may have been due to one or more of several factors of toxicity, persistence and coverage.

Sawfly on Red Pine

The area treated June 22 at Rose Pond, Branford, included the major part of a pure block of red pine, planted in 1922. This plantation is approximately 20 acres in size and the trees now average about 25 feet in height. For the past several years the south-central portion of the stand has been heavily defoliated by larvae of *Diprion frutetorum* and *Lambdina athasaria* var. *pellucidaria*. The crowns of the trees were so thinned in parts of the infested area that a dense ground cover has appeared. This defoliation, supplemented by attacks of secondary insects and a severe drought in 1944, has caused the death of numerous trees. Still others appear not likely to survive.

Although there was an extensive flight of moths in 1944, very few larvae of *Lambdina athasaria pellucidaria* were observed feeding in 1945. Sawfly larvae also appeared to be scarce. However, the block was sprayed with a 12.5 per cent solution of DDT. Boundary flags had been placed to delineate the area to be treated, but wind-drift caused unintentional coverage of approximately the entire block. Cloth trays three feet square were placed on the ground at strategic points throughout the plantation previous to spraying. The trays were collected on June 27, 1945, and a count was made of the dead larvae and miscellaneous invertebrates found on them (see Table 20).

A study of the map of the area and of the table indicates that the sawfly infestation is moving in a north-westerly and north-easterly direction from the original center. This will involve portions of the stand hitherto very lightly infested or apparently uninfested. The count of sawfly larvae by instars shows that 62 per cent were in the second instar. The first, second, and third instars included 96.6 per

Table 20. Dead and Dying Larvae on Trays. Rose Pond, Branford

Tray No.	*Diprion frutetorum* by instars						*Lambdina athasaria*
	1	2	3	4	5	Total	
1	2	15	11	1		29	
2	1	17	2	3	1	24	3, 1st instar
3	2	30	1	1	1	35	3, 1st instar
4	17	34	10			61	3, 1st instar
5	14	25	3			42	
6		7		1		8	
7		14	5	1		20	
8		4				4	1, 1st instar
9 and 10	3	20	11			34	2, 1st instar
11	1	6	6	1	1	15	2, 1st instar
12 and 13	3	23	4	1	2	33	
14 and 15	21	39	5			65	2, 1st instar
16	4	14		1		19	
17		1	4		5	1	
18 and 19	2	13	7	1		23	
20	2	14	8		1	25	
21	23	31	2			56	
Total	95	307	75	11	6	494	

cent of all larvae taken, and only 3 per cent were in the fourth and fifth instars. However, based on the comparative size of the frass pellets on the trays, there were many larvae in the later instars which were not taken. These may not have been killed by the insecticide as used. Only 12 first instar larvae of *Lambdina athasaria pellucidaria* were collected but the sampling error may have been high due to their small size and indifferent appearance when in a desiccated condition. It seems apparent that there was a large population of sawfly larvae in parts of this plantation and that considerable defoliation would have occurred had it not been sprayed.

Potatoes

The potato fields were selected first, for convenience to the designated service fields and, secondly, to obtain approximately ten-acre blocks with adequate checks. In spite of the care of selection and statements by the growers that both treated and check plots had received uniform treatment, in almost every case there were differences either in previous treatment or in treatment during the spray season which ruined any yield effects of helicopter treatments. The data are therefore confined to records of abundance of insects, as obtained by sweeping with a net, following treatment.

After treatments of July 3 and 4, counts were made July 6 and 9. The July 11 treatment was examined July 13. Following the July 12 applications, rain, etc., prevented counts until July 20. No counts were made following the final treatments in August. Various delays prevented application before the insects decreased in abundance naturally. The detailed results are given in Table 21 below.

In most cases the results against flea beetles were reasonably clear-cut. However, the treatments on the Liebman, Wetstone and Mulnite farms did not appear to control flea beetles. The same treatment on the same day worked well on the Bahler farm. These conflicting results may have been caused by the time of emergence of the flea beetles. On both plots at Bahler's, flea beetles were very abundant when the treatment was made. Adult beetles were affected immediately and on the following day the ground between the rows was "black with dead flea beetles". Apparently, few adults emerged between that date and the 20th, when the count was made. The population on the Liebman and Mulnite farms was very low on July 9 and apparently did not build up until *after* the treatment had been made. It is suggested, therefore, that the timing of the treatments in relation to flea beetle emergence was responsible for the apparent failure to control beetles on the Liebman, Wetstone and Mulnite farms.

Populations of flea beetles were extremely low on the Daigle and Steane farms all season. Both growers made June applications of dust to control this pest.

Counts on all farms, particularly the Daigle farm, showed that the residues of DDT were either not heavy or not persistent enough to

TABLE 21. POTATO INSECTS

Location	Treated	Examined	Leaf-hoppers	Aphids	Flea beetles	Plant bugs	Lady beetles	Diptera
Daigle Farm								
Cheshire,	July 3	July 6	16	70	1		4	11
Conn.	Check	July 6	54	99	7		9	10
	July 11	July 13	0	407	0		7	5
	July 3 and 11	July 13	0	64	0		2	5
	Check	July 13	48	628	0		6	8
	July 3 and 11	July 25	41	10	224		12	15
	Check	July 25	50	30	233		16	39
	July 11	July 25	31	21	291		10	32
	Check	July 25	83	25	488		11	29
Liebman Farm	July 4	July 9	8	3	23	2	0	77
Ellington,	Check	July 9	27	7	69	5	0	270
Conn.								
	July 12	July 20	6	28	2615	0	8	52
	Check	July 20	12	50	2263	0	8	37
Bahler Farm	July 4	July 9	0	2	104	1	0	34
Ellington,	Check	July 9	5	4	438	0	5	37
Conn.	DDT Ground Spray[1]		6	4	341	8	0	43
	July 12	July 20	8	42	847	0	6	37
	Check	July 20	2	45	2469	0	1	84
	DDT Ground Spray[1]		8	59	2305	0	9	38
	July 12	July 20	8	54	714	0	10	55
	Check	July 20	18	160	4577	0	11	59
Mulnite Farm	July 4	July 9	3	0	5	0	0	23
East Windsor,	Check	July 9	5	0	11	3	0	41
Conn.								
	July 12[2]	July 20	1	43	2055	0	6	65
Steane Farm	July 4	July 9	6	12	56	2	0	48
Manchester,	Check	July 9	6	24	97	3	2	21
Conn.								
Wetstone Farm	July 12	July 20	10	244	2134	0	9	53
Ellington,	Check	July 20	42	277	1751	0	10	46
Conn.								

[1] About 0.7 lb. DDT per acre
[2] Entire field treated.

kill the beetles as they invaded the fields after treatment. It must be noted, however, that Bahler's conventional spray with about .7 pound DDT per acre per application in the form of a powder was much less effective than the helicopter application in controlling flea beetles.

Leafhopper counts were relatively low all season as most farms used Bordeaux mixture which would keep the population down. However, on the Daigle farm, the helicopter treatments were made on a plot sprayed with Dithane which does not control leafhoppers. The three treatments controlled leafhoppers satisfactorily and no serious hopperburn ever appeared.

No "outbreaks" of aphids occurred on treated farms. In every case treated plots had less aphids than untreated. On the Daigle farm there was an apparent control of 90 per cent following two treatments. Rains caused a rapid drop in the population soon after. This type of treatment apparently has at least some merit in aphid control, and the repeated applications for control of flea beetles might be expected to prevent aphid "outbreaks".

Plant bugs were not abundant in any fields, and treatment usually reduced their numbers.

Counts of coccinellid larvae and adults and braconids were included under "lady beetles" in the tables. There was no indication that the treatment reduced the population of these beneficial insects very seriously. The numbers of all flies were reduced in most cases. Although no effort was made to determine the effect of spraying potatoes on birds, one chipping sparrow seriously affected with symptoms closely resembling DDT poisoning, was found in the Daigle field July 13.

Apple Maggot

An orchard plot was sprayed twice for apple maggot control, but the results were not satisfactory.

Birch Leaf Mining Sawfly

Another failure to get results was on a five-acre plot of birches that were infested with *Fenusa pusillus* Lepeletier, a birch leaf mining sawfly. At the time of staking out the plots, large numbers of adults were present. Spraying took place several days later. An examination of the plot was made two days after spraying and no adults could be found either alive or dead on the cloth mats pegged to the ground. This was also true of check plots, so that no conclusions could be drawn on the effect of the DDT.

Japanese Beetle

On the morning of August 13, 1945, the helicopter sprayed a 10-acre wood lot in the town of Bloomfield for the control of Japanese beetles. Cloth mats were placed under the following five species of trees: sweet cherry, elm, gray birch, linden and sassafras. All of these are especially attractive to Japanese beetles and were, at the time of treatment, considerably damaged by beetle feeding. A heavy population of adult beetles was present the morning the DDT was applied. Beetles began to fall to the ground within a few minutes after the spraying started and were observed lying on their backs and kicking, not only on the cloth mats but also on the ground in the vicinity. Many of the beetles were collected and placed in containers for observation. One hour after the spray was applied some of the Japanese beetles seemed to be recovering from the effect of DDT while others appeared to be dead.

At 12:30 P. M., or two hours following the spray application, beetles continued to fall to the ground. At this time some of the beetles that had been picked up and placed in containers a few minutes after the spray was applied were still kicking, others were quite lively and still others appeared to be dead.

At 5:00 P. M. beetles fell to the ground as they came in contact with sprayed foliage. At this time it was estimated, from counts made throughout the day of beetles that had fallen to the ground and either recovered or died, that only about 10 per cent mortality resulted from DDT during the first few hours after application.

The following day, August 14, a number of Japanese beetles were seen on the ground under the sprayed trees. Some of these were dead, while others were kicking. A few of the dead beetles may have fallen the previous day. However, there were fewer beetles on the ground on the 14th than on the 13th. Certain sprayed trees showed no beetles whatsoever, whereas beetles were seen on the foliage of other trees. A five-leaf ivy in one section of the wood lot was covered with beetles and in another section no beetles were seen on the same species of vine. At the time of the spray application the wind was blowing, consequently, certain parts of the wood lot received more spray than other sections and by the same token some areas received none at all. This will perhaps help to explain in part, at least, the variations in results.

On August 17, a few dead beetles were found under the trees. However, no beetles could be seen on the following trees: cherry, birch and linden. A sassafras that had been definitely sprayed with the DDT showed few beetles feeding. On August 21, no beetles could be found on the cloth mats or on the ground. There were many more beetles feeding in the trees than on the 17th. Apparently, beetles had come back to the wood lot in large numbers and seemed to be suffering no ill effect from the DDT, at least no beetles could be seen falling to the ground. On August 28, large numbers of beetles were seen feeding on the sprayed trees, especially so on five-leaf ivy, sassafras and linden.

Orange-striped Oak Worm (*Anisota senatoria* S. and A.)

On August 28 three plots of oaks of five acres each were sprayed to control the orange-striped oak worm. At this time the larvae were in the third to last instar, in fact a few had pupated. Control was not considered good. If the spraying could have been done earlier while larvae were smaller and before the trees were severely defoliated, the results might have been better.

Mosquitoes

A series of concerts was scheduled to be held in Yale Bowl during July and August. We anticipated that mosquitoes would be a nuisance to the audience so it was decided to spray the Bowl and surrounding land the day before the first concert to determine the practicability of this type of mosquito control.

The evening before spraying, three of our staff visited the Bowl and collected many mosquitoes in a short period of time. The evening of the concert the Bowl appeared free of mosquitoes. The audience was watched carefully, but no evidences of mosquitoes were seen. We talked to people in the audience and all agreed that they were not annoyed by these pests. It was also noted that there was a scarcity of insects around the lights over the musicians. People who lived in the neighborhood remarked about freedom from mosquitoes for nearly two weeks. Only one mosquito was seen the night of the concert and that was in a refreshment stand. It could have been inside the building when the spraying took place. About five days after treatment, mosquitoes began to appear in the Bowl.

For later concerts a ground sprayer was used until the last event, when the helicopter sprayed the entire Bowl again as well as some of the surrounding area. The control was excellent, as before.

Discussion

The helicopter as an apparatus for applying insecticides has certain advantages when compared to the winged type of plane. It does not require a large landing field. In actual practice this machine alighted in and took off from such places as the middle of an orchard, a clover field, the center of our farm at Mount Carmel, etc. It is very maneuverable and operates well on relatively small areas. The insecticide was distributed satisfactorily as far as the machine is concerned. The failure to kill insects in some cases cannot be attributed to an unsatisfactory deposit of the spray.

The disadvantages are quite obvious, but some of them can be overcome. The machine we used had a load capacity of 30 gallons and flew at a slow speed. It is fully as difficult to fly as a winged plane and the pilot has to concentrate on his job every minute he is in the air. Moreover, the cost of the helicopter is rather high.

MIST BLOWERS FOR APPLYING CONCENTRATED SPRAY

S. F. Potts[1] and R. B. Friend

The conventional method of spraying trees to control insect pests involves the application of large volumes of dilute insecticidal mixtures with powerful high-pressure sprayers, which is expensive in labor, material, equipment, and time. From 10 to 40 gallons of standard lead arsenate spray (five to 20 ounces of insecticide) are required

[1] Entomologist, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

to cover the foliage of a well-developed street tree. This means eight to 30 trees per 300-gallon tank. Moreover, the application of large quantities of spray, even to the extent that excessive run-off occurs, does not by any means assure thorough and uniform coverage.

The development of a mist blower which will apply thoroughly a small quantity of a concentrated insecticide is the logical result of an effort to overcome relatively cumbersome methods. Such an apparatus should atomize the spray adequately; give good and rapid coverage with a small volume; project the mist up to 100 feet vertically and 200 to 300 feet horizontally (in quiet air); deliver solutions, emulsions or suspensions, and be light in weight as compared with standard sprayers.[1]

The idea of applying relatively small quantities of insecticides in the form of finely divided mist, using a blower, is not new. In 1928 Potts used an orchard duster to apply oil-coated dust and concentrated sprays atomized into the discharge pipe. This work was preliminary in nature, and inadequate air volume and velocity restricted the projection of either dust or spray to a height of 35 to 40 feet.

In 1934 French (1) published a description of blower equipment for applying atomized oil sprays. Among other things, he was interested in droplet size, particularly since he was applying a contact insecticide. The oil was partly atomized by passing it through a disk nozzle under pressure and further atomized by an air blast of large volume and high velocity. French determined the relations between (1) gallons per minute, quantity per acre, and speed of travel of his machine; (2) gallons per minute, pressure per square inch, and size of nozzle; (3) oil pressure and droplet size, and (4) air velocity and droplet size.

In 1942 French (2) described two types of air-atomizing ground sprayers for applying concentrated sprays to vineyards and orchards, a compressed-air sprayer and a mist blower. He gave specifications for air pressure, volume and velocity, and emphasized the importance of droplet size. One of the machines described by French is the type used by us after being modified to project the mist a greater distance and equipped with different nozzles.

The apparatus described below is still in the developmental stage and is, of course, subject to further modification and to standardization, particularly in respect to the relation of deposit to control. It was developed primarily for treating shade trees and young forest plantations, or limited areas of more nearly mature forest stands, but it may well be found useful for other purposes. Rather than build a blower of original design, we borrowed a "vapo-duster" and an or-

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[1] Since interest in this type of blower has been stimulated by the work of Potts, at least two designs have been placed on the market.

chard duster and installed the pressure nozzles on the modified air blast orifice.[1]

The "vapo-duster" had a 25-horsepower motor driving a fan which delivered about 8,730 cubic feet of air[2] per minute at an outlet velocity of about 124 miles per hour.[3] (Figures 6, 7 and 8.) It

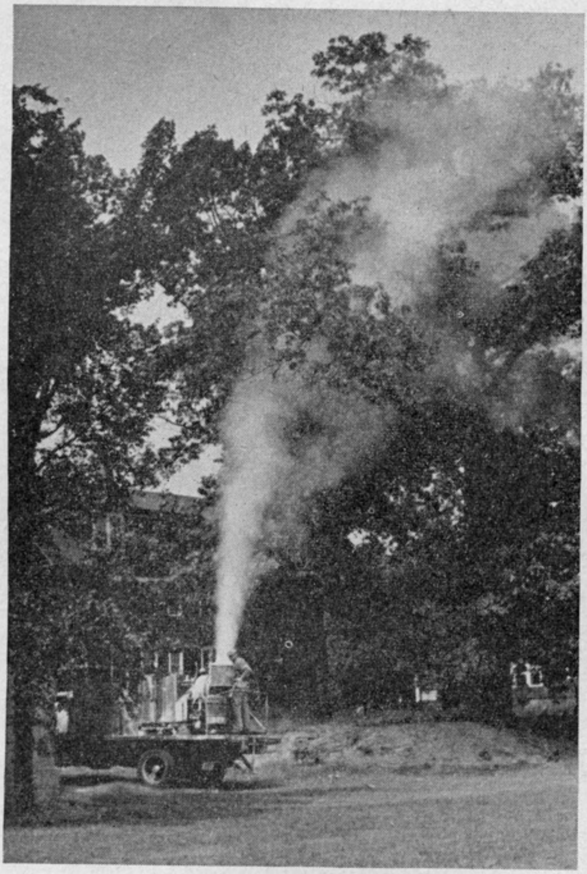

Figure 6. Twenty-five-horsepower blower-atomizer treating an 80-foot red oak, using 12-inch-diameter discharge tube. A small amount of dust was added to facilitate photographing.

was modified by removing the fishtail outlet and replacing it with a short cylindrical discharge pipe 12 inches in diameter. Since only

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[1] The authors are indebted to H. G. Ingerson and W. J. Norton of the John Bean Manufacturing Co., to T. C. Matteson of Wethersfield, Conn., and to C. O. Eddy of the Niagara Sprayer and Chemical Co. for the loan of equipment and for valued suggestions and advice, to J. H. G. Fraser, who made several special nozzles, and to R. Spencer of the Connecticut Agricultural Experiment Station, who rendered valuable assistance in the tests and made some of the equipment.

[2] Cubic feet per minute $= 4005\ \sqrt{Pt} \times \frac{\pi\ r^2 \times 12}{1728}$

[3] Velocity $= \frac{4005\ \sqrt{Pt} \times 60}{5280}$ m. p. h.

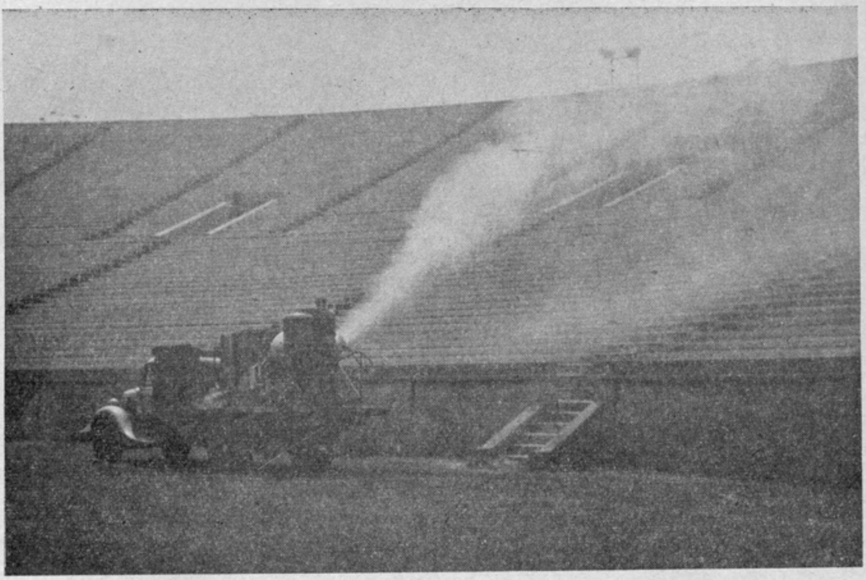

Figure 7. Twenty-five-horsepower blower-atomizer treating interior of Yale Bowl for control of mosquitoes.

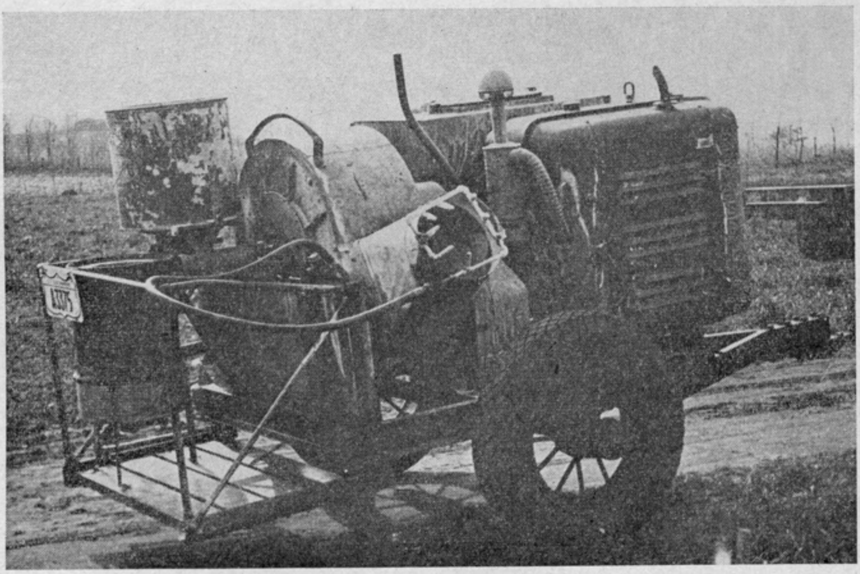

Figure 8. Twenty-five-horsepower blower-atomizer on trailer showing (1) large and (2) small tank, (3) dust hopper, (4) hand-operated spray shut-off lever, and (5) ring of 8 oil-burner nozzles mounted in discharge outlet at a 45° angle to air blast.

small quantities of insecticide were to be used, a 15-gallon tank was installed. The orchard duster had a 12-horsepower motor driving a fan which delivered 1,200 cubic feet of air per minute at a velocity of 150-175 miles per hour. (Figure 9.) Its discharge tube was modified by placing over the end a sleeve carrying the nozzles and necessary tubing. A five-gallon and a 14-gallon tank were installed.

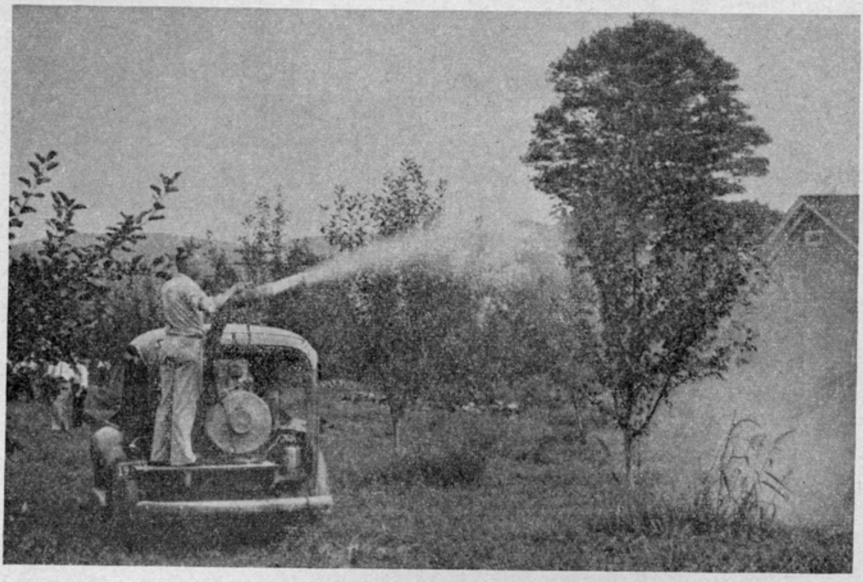

Figure 9. Twelve-horsepower high-velocity blower-atomizer treating orchards, using flexible 4-inch-diameter discharge tube.

A gear pump capable of delivering up to five gallons per minute at 80 pounds' pressure, together with a ¾-horsepower engine to run it, was installed in each of these machines. These gear pumps are satisfactory when solutions or emulsions are used, but will not stand the abrasiveness of many suspensions. Plunger pumps are probably best for all mixtures and pressures. One of these, delivering up to four gallons per minute at 250 pounds' pressure, was installed on the "vapo-duster".

The proper nozzle arrangement is a complicated problem, for not only are the output and droplet size affected by the pressure and nozzle design, but the angle at which the nozzle directs the insecticide into the air stream of the blower is also important. We have used two kinds of nozzles, a direct-pressure type which delivers a fairly fine spray into the air stream, and a so-called "air-velocity" nozzle which delivers the insecticide at low pressure into the air stream, all the atomization being caused by the air stream.

Two designs of direct-pressure nozzles have been found satisfactory. In one design a number of conventional oil-burner nozzles, having apertures of 0.018, 0.02, and 0.027 inch for delivering 1.8, 2.7, and

5.0 gallons per hour per nozzle, respectively, at 80 pounds' pressure, were arranged around the blower orifice and usually set to feed a spray into the blower air stream at an angle of 45 degrees (Figure 10). In a second design a single nozzle, with an orifice 0.086 inch in diameter was set inside the air-stream orifice and directed to feed a spray directly against the air stream at 150 to 250 pounds' pressure and about one-gallon per minute (Figure 11). The spray from direct-pressure nozzles is, of course, broken into finer droplets by the air stream of the blower.

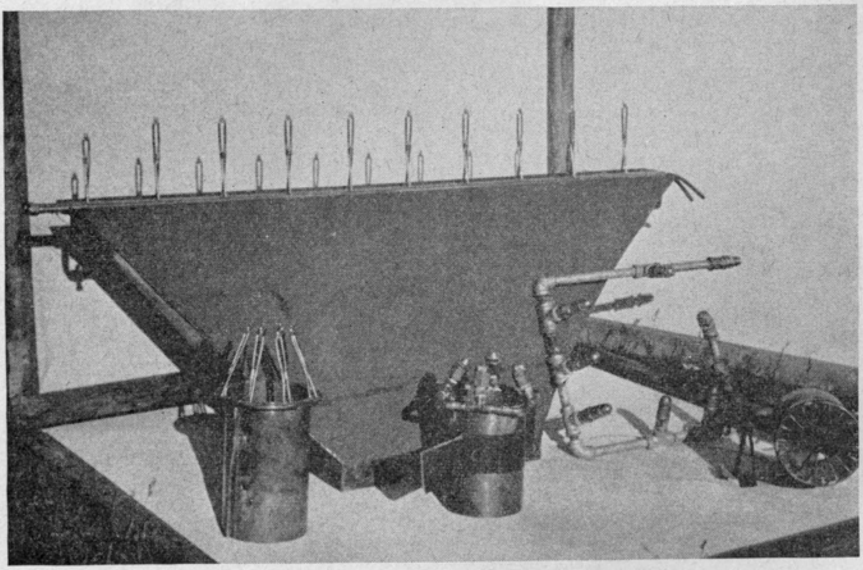

Figure 10. Nozzle manifolds. Top: Ten No. 152 DeVilbiss nasal-atomizer nozzles mounted on a fishtail outlet, 38" x 3-1/2". Bottom, left to right: (1) 8 DeVilbiss nozzles on 4-inch diameter manifold, (2) direct-pressure atomizing nozzles with interchangeable tips of different sized orifices set at 45° angle to air blast, (3) direct-pressure atomizing nozzles for 12-inch-diameter discharge outlet, and (4) air-velocity nozzle with 18 1/16-inch-diameter capillary tubes for applying atomized spray or spray-dust. The DeVilbiss nozzles gave insufficient volume of spray and were discarded.

The "air-velocity" nozzles (Figure 11) consisted of groups of capillary copper tubes of 1/16-inch inside diameter, arranged so that they projected into the air stream at right angles to it. The insecticide was delivered at five to eight pounds' pressure. The atomization was effected entirely by the shearing action of the air stream. One of the "air-velocity" nozzles could be rotated through an arc of 180 degrees; so the position of the tubes with respect to the direction of the air stream could be changed. In another type the speed of the air stream across the openings of the tubes could be changed by moving a deflecting cone forward or backward.

Several insecticidal mixtures have been applied with this apparatus. That most frequently used was a solution of one pound of DDT

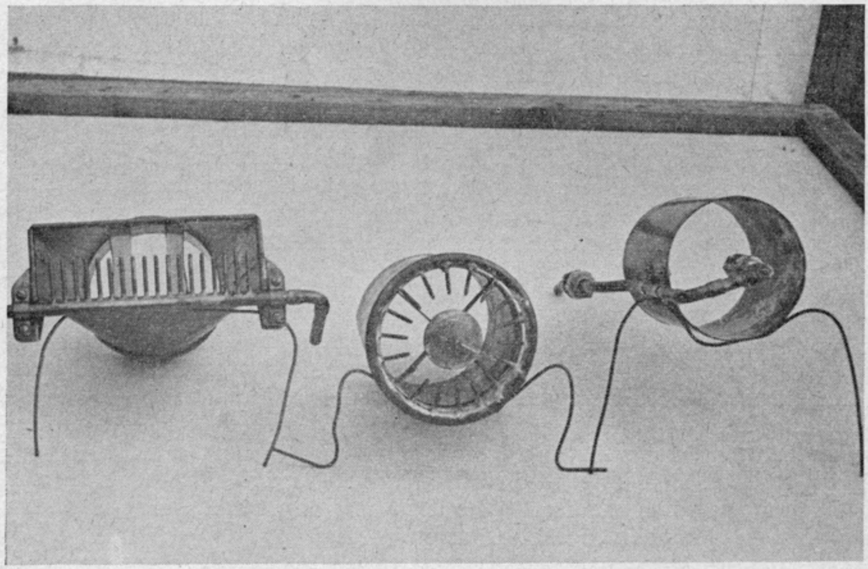

Figure 11. Left to right: (1) An air-velocity nozzle with mechanism for regulating the size of droplets by changing the position of the capillary tubes with respect to direction of air blast; (2) air-velocity nozzle with adjustable cone in center for increasing the speed of air flowing across the nozzle orifices; (3) a special type of conventional whorl nozzle reversed against the air blast (using 150 to 250 pounds direct pressure), and constructed for attaching different-sized tips.

in one quart of xylene plus three quarts of kerosene or horticultural base oil, giving approximately a 12 per cent concentration of the DDT. For some applications, this solution was diluted with an equal volume of kerosene to make a 6 per cent DDT concentration. The DDT was also dissolved in kerosene or fuel oil at the rate of 0.5 pound per gallon. Emulsions containing about 5 and 10 per cent of DDT were tried, but to obtain good results when the mist is blown long distances some non-volatile liquid, as a mineral oil, should be included in the formula. Other insecticides applied, using either water or oil carriers, included pyrethrum extract, rotenone (derris or cubé), nicotine sulfate, nicotine alkaloid, benzene hexachloride, and lead arsenate. Some of the mixtures mentioned, particularly the DDT solutions, would cause foliage burn if applied in any great quantity, but small amounts, which cause no visible injury to foliage but are lethal to insects, can be successfully applied with the blower. This is made possible mainly by the small size of the droplets produced.

Particle size,[1] important in the application of any spray, if for no other reason than its significance in respect to deposit, is affected by characteristics of both equipment and insecticide. The size of drops coming from the nozzle is reduced by the air blast in the air-

[1] Volume of drop = 4.2 R^3 (R = radius of drop).

discharge tube. An increase in the air velocity increases atomization. The air blast apparently has its greatest effect on drop size when the spray from the nozzle is projected in the direction opposite to the air blast. The drop size is also affected by the pressure at the spray nozzle, greater pressure resulting in larger size with "air-velocity" nozzles and smaller size with direct-pressure nozzles. In case the latter nozzles are used, the drop size can be reduced one-half by reducing the nozzle orifice one-half and maintaining the same pressure, but with the same orifice the pressure must be about quadrupled to reduce the droplet diameter one-half.

Increasing the diameter of the air-blast orifice increases atomization. The continued breaking up of drops in the air stream for some distance from the outlet is due to the maintenance of a high velocity, made possible by the large volume of moving air. For example, the same average drop diameter (37 micra) was produced when kerosene was sprayed through a whorl disk nozzle with a 0.086-inch orifice at 200 pounds' pressure against a 150 mile-per-hour air blast in a four-inch diameter air outlet, as against a 120 mile-per-hour air blast in a 12-inch diameter outlet.

The composition of the insecticide obviously affects the size of the droplets. A light oil sprayed at 250 pounds' pressure through a 0.086-inch nozzle orifice against an air blast of 120 miles per hour produced an average particle size of 36 micra. With the same apparatus and pressure, the average particle size of lead arsenate and cryolite concentrates was about 50 micra. The addition of a wetting agent, such as Santomerse D (essentially decylbenzene sodium sulfonate) at 0.02 pound per pound of insecticide reduced the diameter of drops to 42 micra in the lead arsenate and cryolite mixtures. A suspending agent (Daxad No. 14, a salt of polymerized arylalkylsulfonic acids) slightly increased the drop diameter. An increase in the viscosity of the oil from 50 to 200 Saybolt seconds nearly doubled the drop diameter.

The mere fact that certain size drops leave the air outlet does not imply that the same size drops are deposited on the surface to be sprayed. When the insecticide leaves the air-blast orifice, the drops vary in size and in the proportion of drops of different sizes. The larger drops continue to shatter while traveling through the air some distance from the orifice. As this distance increases, the spray stream expands, air dilution increases, and the proportion of drops of different sizes changes. The larger drops, of course, tend to settle out of the air stream and deposit first. Therefore, foliage near the machine may receive a heavier deposit than that farther away unless the air outlet can be modified so as to divert and distribute a small part of the spray near the blower. For example, an oil having a Saybolt viscosity of 40 seconds was projected by an air blast of 120 miles per hour parallel to the ground. Samples of the spray were taken on exposed glass slides three feet above the ground in the center of the stream. At 25, 50, and 100 feet from the blower, the mass average diameters of the drops that deposited on the slides were 42, 38, and

36 micra, respectively, a reduction in volume per drop of 38 per cent in traveling a distance of 100 feet. Samples taken in the settling box 50 feet from the blower outlet showed that 9 per cent of the spray volume and 31 per cent of the number of drops were too small to deposit on a perpendicular glass slide. At distances of 25, 50, and 100 feet, the numbers of drops deposited per square millimeter per second were 300, 44, and 16, respectively. At drop sizes of 20, 30, 40, 50, 60, 70, and 100 micra average diameter, it would be necessary to obtain, respectively, 222, 65, 28, 14, 8.2, 5.2, and 1.78 drops per square millimeter to equal one gallon (3,785,000,000,000,000 cubic micra) per acre of surface.

If air-borne drops are to be carried to great heights and drift for long distances, at the same time providing good coverage, the drops must be very small. However, they must be sufficiently large to deposit on foliage and insects. Under conditions normally met out of doors, most drops less than 20 micra in diameter do not deposit on the surface of leaves. A mass average diameter of 35 to 60 micra appears to give the best deposit for most conditions. Some conception of the mass of drops when distributing a certain volume of spray material can be obtained when it is realized that cutting the drop diameter in half reduces its volume seven-eighths and hence increases the number of drops eight times, a ratio of the cube of the diameter.

To compare drop sizes under different conditions, certain standardized techniques must be employed. To determine the size of drops deposited, coated glass slides were used. The coating was cellulose nitrate, 2 per cent ferric stearate in benzene, or DRI-FILM.[1] All of these materials reduced the spreading of the drops on the slide. The drop diameters were measured through a microscope using an ocular micrometer grid, and the number per square millimeter was recorded. With these data, it is possible to compute the volume of spray deposited per unit of area.

The glass slides were placed in certain types of apparatus to make certain that all sizes of drops could be measured. To determine the deposit on a vertical surface, an apparatus based on a focal-plane shutter plan was employed (Figures 12 and 13). A pair of rollers, or cylinders, was set for running a strip of clean photographic film at a uniform speed in front of the glass slide. Slots of definite width in the strip permitted exposure of the slide for a definite length of time. Thus, with the strip moving 11 centimeters per second, a slot one centimeter wide exposed the slide 0.09 second; and a slot five centimeters wide exposed it 0.45 second.

Extremely small drops do not deposit well on vertical surfaces under field conditions. Therefore, with the apparatus described above, by no means all of the spray material delivered was measured. To determine the size and number of minute drops which would not so deposit, as well as the proportion of the spray deposit they represent,

[1] Product of General Electric Co.

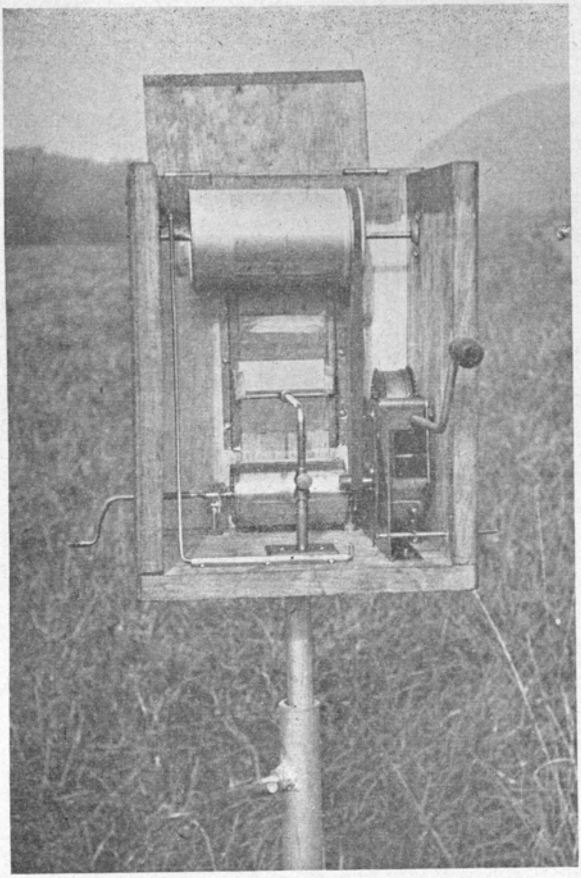

Figure 12. Interior view from back showing apparatus for obtaining particle-size samples by timed exposure of prepared microscope slide exposed at the front center of the box. The two rollers at the top and bottom of container are turned by a phonograph spring located in the lower right corner of the box.

a wooden box with a hinged door open at each end was set horizontally in the spray stream (Figure 14). The doors of the box were closed simultaneously and the box was rotated to a vertical position. The enclosed mist then settled down on the inner side of the bottom door, where an oleophobic slide (1 x 3 inches) had been fixed. The settling period was 13 minutes. Measurements of samples so collected showed that, when the median mass diameter of the drops fell below 30 micra, much of the spray was not deposited on vertical surfaces. With an average drop diameter of 13, 16, and 10 micra, a loss of 22, 65, and 94 per cent of the spray volume occurred as compared to the deposit on a vertical slide in the apparatus described in the preceding paragraph.

Figure 13. Front view of apparatus shown in Figure 12 in position for taking a particle sample.

Other factors, such as physical nature of the spray material, relative proportion of the ingredients, and meterological conditions, also affect the drop size. Optimum size of drops depends on many things —the insect to be controlled, the dosage and gallonage needed, the rate of drying the mixture, the drift and width of swath desired, etc.

Operation of Equipment

The height to which the blower will deliver the spray mist is important. The orchard duster drove the spray to the tops of 50-foot trees provided the wind did not exceed four miles per hour. This was an advantage in certain types of orchards where the machine was close to the trees. The "vapo-duster" could drive the spray to a height of 100 feet in quiet air, or 75 feet against a five-mile-per-hour wind. It

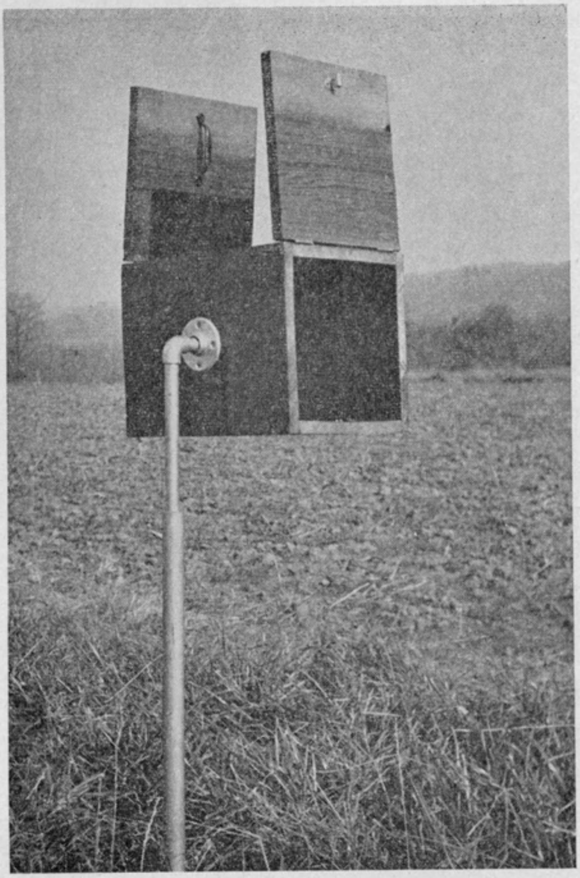

Figure 14. View of particle settling box when in position to trap a particle sample. Slide is placed in a holder in the back door.

could drive the spray horizontally for a distance of several hundred feet, depending on wind conditions. The movement of either machine has the same effect as moving air currents; that is, greater distance is attained when the machine moves slowly than when rapidly. The orchard duster was equipped with a flexible outlet pipe which permitted directing the spray in any direction, forward or backward, as well as up or down. The outlet on the "vapo-duster" could be rotated in one plane through an arc of 180 degrees to cover foliage from the ground up on either side. It could not project the spray backward or forward.

Results Against Insects

Dosages of DDT as low as 25 micrograms per square inch were completely effective against the gypsy moth [*Porthetris dispar* (L.)]

throughout the larval period. Thirty-two plots were treated, 12 of which were roadside or woodland plots, comprising a total area of 50 acres. Along roadsides, two to five ounces of DDT were applied to 100 linear feet. The concentration was one pound of DDT in one quart of xylene and three quarts of kerosene—a 12 per cent DDT mixture. The dose of two to five ounces gave good control for at least 200 feet from the machine in the absence of a contrary wind. Average figures for all plots gave an average DDT dose of 0.43 pound per acre, that is, an average volume of about 0.5 gallon. This gave nearly complete control in all tests. On the larger trees, for instance, oaks 85 feet high, a pint of solution (two ounces of DDT) per tree was sufficient to control the gypsy moth, spiny elm caterpillar [*Malacosoma americana* (F.)], forest tent caterpillar (*M. disstria* Hbn.), orange-striped oak worm (*Anisota senatoria* A. and S.) green-striped maple worm [*Anisota rubicunda* (F.)], fall webworm [*Hyphantria cunea* (Drury)], and the Japanese beetle (*Popillia japonica* Newm.) The tent caterpillar was slightly more resistant than the gypsy moth, but the fall webworm and certain May beetle (*Phyllophaga* spp.) adults were very susceptible. For Japanese beetle control, it may be necessary to spray twice during the season.

Mosquito control has been excellent in the tests made. The Yale Bowl and the surrounding area, comprising altogether about 25 acres, were treated twice to keep out mosquitoes during evening concerts. The dosage was one pound of DDT in one gallon of solution per acre. After treatment, the Bowl remained free of mosquitoes for at least five days. A 12-acre suburban block treated with the same dose remained free of mosquitoes for 10 days. We received no complaints from residents of the block regarding residues on automobiles, buildings, etc.

In cooperation with the Division of Fruit Insect Investigations of the Bureau of Entomology and Plant Quarantine, 23 plots were treated for the control of the pear psylla, the insecticide in this case being nicotine alkaloid (99 per cent pure) at the rate of 16 ounces per gallon of kerosene. Applied at four to eight ounces per pear tree, this mixture gave a control of adults of 90 to 96 per cent.

Economy of Operation

In treating the average New England hardwood forest, which contains four to six acres of foliage per ground acre, 20 to 30 pounds of lead arsenate are usually applied per acre with solid-stream, high-pressure sprayers. At three to five pounds per 100 gallons, this means 400 to 1,000 gallons per acre, 35 to 60 per cent of which misses the foliage, runs off, or otherwise ends up on the ground. The cost per acre for equipment, labor, and insecticide is about 20 dollars, and 10 acres can be treated per day with one sprayer and a crew of 10 men.

When suitable adhesives and wetting and dispersing agents are used, five pounds of lead arsenate can be suspended in one gallon of water and applied with a blower so that only four to six gallons of insecticide per acre are required. If a DDT concentrate is used, excellent control of the gypsy moth may be obtained with 0.5 pound of DDT in one gallon of kerosene per acre, costing about 40 cents per acre for materials. From 20 to 48 acres may be covered per hour at a total cost of about 75 cents per acre. This all assumes that roads are available so the machine can reach the woods.

In spraying shade trees for cankerworm and elm leaf beetle control, large elms usually require 10 to 20 gallons, or more in some cases, of diluted spray. This means that 20 to 40 trees could be covered per 400-gallon tank. With a suitable blower, it is possible to deposit the same quantity of lead arsenate on the tree, and more quickly, with one quart of concentrate. When the delivery rate is 30 gallons of concentrate per hour, trees receiving 2, 1, ½, ¼, or ⅛ pint of spray per tree, require 30, 15, 7.5, 4, and 2 seconds of spraying time, respectively, per tree. A 100-gallon tank could cover 800 trees at one pint per tree, and the same amount of material is enough for 100 acres at one gallon per acre.

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(2) French, O. C. 1942. Spraying Equipment for Pest Control. Calif. Agr. Expt. Sta. Bul. 666, 42 pp.

ADULT JAPANESE BEETLE SPREAD AND INTENSITY OF INFESTATION IN CONNECTICUT IN 1945

John C. Schread

Japanese beetle infestation in Connecticut during the summer of 1945 showed varying degrees of intensity, attributed in part to the severe drought in the previous summer of 1944. The dry season in question was more protracted and severe in the southwestern part of the State, in Fairfield and New Haven counties, than elsewhere in Connecticut. However, most of the State felt the scarcity of rain for at least part of the season.

The effect of the drought on the Japanese beetle was two-fold. First of all, turf areas became dry and brown and consequently unattractive to adults for oviposition. Secondly, if and when Japanese beetle eggs were deposited in such a situation or in ground which later became parched, they either dried out and failed to hatch or the first instar larvae died. It became evident that in the shore towns in Fairfield County many grubs that succeeded in reaching the second instar, owing to early deposition of eggs, died later in the season. It would appear that in certain other sections of the State, for example, upper New Haven County, Litchfield County and parts of Hartford County, there was sufficient rainfall to keep the ground reasonably moist and thus suitable for Japanese beetle grub development.

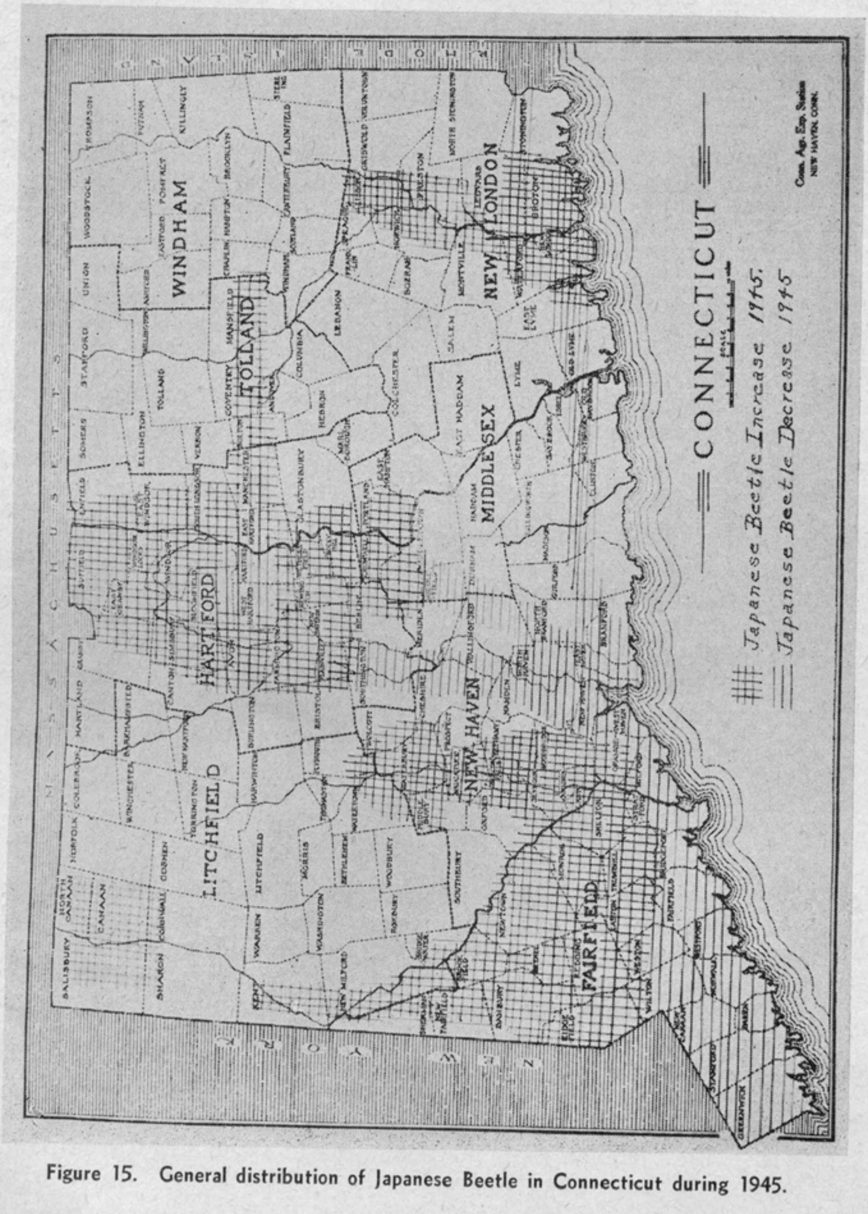

Figure 15. General distribution of Japanese Beetle in Connecticut during 1945.

The accompanying map of Connecticut (Figure 15) gives a reasonable picture of the Japanese beetle infestation in much of the State in 1945. Evidence at hand indicates that the beetle infestation is practically negligible in the towns in the eastern part of the State from North Stonington along the Rhode Island State line to Thompson on the Massachusetts State line. Beetles were not found in most of Windham and Tolland counties. In some of the towns in these counties, none has ever been seen. In many towns in Middlesex and Litchfield counties beetles were not abundant, and in most cases evidence of feeding on certain favored host plants was absent or difficult to find.

In general, the Japanese beetle situation in 1945 in the sections of the State which were scouted is indicated in the following notes.

Danbury: West to New York State line—feeding light to very heavy in trees. Damage more severe and more general than in 1944. In fruit orchards west of the city of Danbury, early peaches and Elbertas ripening in September were attacked by adult beetles. Upward of 5 per cent of the foliage was damaged.

West Haven, Orange, Milford, Devon: From West Haven, west to and including Devon, infestation much below that of 1944. Feeding in trees extremely light in contrast to heavier feeding in 1944.

Stratford, Bridgeport, Fairfield: Infestation was far below that of 1944. Feeding in trees negligible. Feeding on other types of vegetation very light.

Nichols: Infestation considerably less than in 1944. Light feeding in trees. Heavy, spotty feeding in grapes. Damage receding in north and northeast section of town.

Southport, Westport, Norwalk, Darien, Noroton: Southport west, including all towns to Stamford town line. Beetle abundance greatly reduced from 1944. Feeding much less extensive, especially in trees—where an average of less than 5 per cent of the foliage was injured.

Stamford, Riverside, Cos Cob, Greenwich: Infestation and extent of feeding greatly reduced over 1944. Especially in trees where, on an average, only a trace of feeding could be found.

Hamden, Mount Carmel, Cheshire, Milldale, Plantsville, Southington, Plainville, Farmington, Avon, Simsbury, Granby: Infestation much less than in 1944. It gradually reduces from Hamden north but becomes quite heavy in Farmington, only to decrease again as the Granby line is approached. Farmington is the center of infestation in this area.

New Haven, Derby, Shelton, Ansonia area: New Haven, west through West Haven and Orange had a greatly reduced population in comparison with 1944. Beetle population considerably less in West Haven than farther north in Orange. Beetle population in Orange slightly greater than at the Derby-Orange town line. Population in East Derby and the eastern side of Ansonia considerably less than in the western and northern section of Derby. Population in northwest and western part of Shelton very heavy. South Shelton not quite as heavy as in the other sections of the town. Extensive feeding in trees in Shelton with the exception of the southern part of the town.

However, the beetle population in Shelton, Derby and Ansonia, for the most part, is considerably less than it was the previous year. Unquestionably, Japanese beetle infestation in the lower Naugatuck Valley has progressed more rapidly during the last three years than it did during the previous six to eight years.

The area south of Shelton Center, to and including the northeastern section of Stratford adjacent to the Housatonic River, shows the Japanese beetle infestation dropping down much below that of Shelton proper until the Stratford-Shelton town line is approached, at which point there is every indication of a measurable rise of beetle population revealed in the type of vegetation attacked and the degree of injury. Japanese beetle infestation declining rather abruptly from northwest Shelton to a point about half way between Shelton Center and Huntington Center where it reaches the zero point. From there to Huntington Center, a slight rise in beetle population is perceptible until in Huntington Center beetles were sufficiently abundant to cause light damage to trees.

Danbury, New Milford, Kent area: Increased beetle abundance over 1944 in the entire area, feeding gradually disappearing on approach to Cornwall-Kent town line. No beetles found or reported in Cornwall—no perceptible feeding on any type of vegetation.

New Haven to Hartford area—via Middletown and Rocky Hill: Beetle infestation apparently not as heavy as in 1944. The heaviest damage occurs in the section including Middletown and Cromwell. This is noticeable not only on herbaceous vegetation, but also on trees.

Hartford north to Massachusetts State line: Infestation decreases gradually as State line is approached. Damage is especially noticeable in the vicinity of East Windsor and Enfield.

New Haven north to Hartford and east to Danielson: Extensive feeding on shrub and herbaceous foliage noticed in Berlin and Manchester areas. Beetle population fairly constant, damage to foliage about 5 per cent, up to Willimantic where it rapidly decreased with no beetle damage evident from Hampton to Danielson. Feeding light up to North Haven from New Haven. Then decreased from North Haven to Meriden where it sharply increased to 5 per cent and held there until the Berlin area.

New Haven to New London area: Amount of injury to foliage by feeding remained from 3 to 5 per cent until Guilford where it was difficult to find evidence of infestation. The amount of feeding, though scarce, fluctuated but little, disappearing entirely around Madison. Evidence began to show near Clinton only to disappear near Saybrook, being hard to find but gradually increasing with a sharp rise at Waterford where feeding and infestation were extensive. Infestation decreased slightly as the Rhode Island State line was approached. The infestation and feeding showed a decided drop from that of 1944.

Groton-Thompson area: Beetle infestation and feeding moderate from Groton to Norwich. Signs of feeding gradually diminished between Norwich and Jewett City, at which point no trace could be found. This condition existed from Jewett City to the State line with the exception of Putnam where feeding and infestation were noticed.

MILKY DISEASE EXPERIMENTS OF FOUR TO SEVEN YEARS' STANDING

JOHN C. SCHREAD

Owing to the severe drought of 1944, no grubs could be found in many of a large number of "milky" disease plots established from four to seven years ago. This was due to drying out of the soil causing a desiccation of the Japanese beetle eggs laid therein or the starvation and drying up of the first instar grubs hatching from unharmed eggs. In certain cases the soil became unattractive to adult Japanese beetles because of the parched condition of the earth, and no eggs were deposited.

It may be seen in Table 22 that a high incidence of disease continues to occur in Hartford County in comparison with Fairfield County. This has been true from year to year since the experiments were first laid out. It is regrettable that a quantity of data could not be had for the three principal counties of the State. However, it appears that the trend in Japanese beetle grub control in experimental plots has been progressive for the past few years.

In 1940[1] 3.1 per cent disease was recorded for all experimental plots in the State; in 1942, 10.7 per cent and, in 1943, an average of 19.6 per cent, including checks, was recorded for Connecticut. The 1943 average for the State showed a rise to 24.08 per cent disease in the treated plots. The following year, 1944, the disease reached 46.5 per cent of the totals. The 1945 record of 41.5 per cent disease average for the State is only slightly below that of 1944. Obviously, the "milky" disease is playing a considerable part in reduction of Japanese beetle grub population where the bacterium has been established for a number of years.

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[1] Garman, P., 1943; Conn. Agr. Expt. Sta. Bul. 472.

TABLE 22. RESULTS OF EXAMINATION OF MILKY DISEASE EXPERIMENTAL PLOTS, 1945

Location of experiment	Date experiment was established	Date of examination	No. grubs found	Ave. grubs per sq. ft.	No. grubs examined	No. grubs diseased
Seaside Park Bridgeport Plot C	Oct. 17, 1939	June 18	0	0	0	0
Tamarack Country Club Greenwich	Nov. 7, 1940	June 20	24	1.2	22	2
Cummings Park Stamford	Oct. 29, 1940	June 22	8	2.5	8	1
Brooklawn Country Club Bridgeport	Oct. 26, 1940	June 25	1	.04	1	0
Stamford Hospital	May, 1941	June 26	0	0	0	0
Keney Park Hartford	May 13, 1940	June 27	16	1.2	15	7
East Hartford Country Club	May, 1941	June 29	32	2.6	31	22

TABLE 23. CHECK (UNTREATED) PLOTS, 1945

Location of experiment	Date experiment related to check was established	Date of examination	No. grubs found	Ave. grubs per sq. ft.	No. grubs examined	No. grubs diseased
Seaside Park Bridgeport Plot C	Oct. 17, 1939	June 18	20	2	7	2
Tamarack Country Club Greenwich	Nov. 7, 1940 Check 600 ft. from experiment	June 20	17	2.8	15	0
Cummings Park Stamford	Oct. 29, 1940 Check 150 ft. from experiment	June 22	1	14	1	1
Brooklawn Country Club Bridgeport	Oct. 26, 1940 Check 100 ft. from experiment	June 25	8	1	8	4
Stamford Hospital	May, 1941 Check 100 ft. from experiment	June 26	5	1.6	5	0
East Hartford Country Club	May, 1941 Check 450 ft. from experiment	June 29	4	2	4	0

TOLERANCE OF GREENHOUSE BENCH ROSES TO DDT IN THE SOIL

J. P. Johnson

The soil in the benches of growing greenhouse roses was treated with DDT at various concentrations to observe the tolerance of the plants to the insecticide. This work was done in the greenhouses of A. N. Pierson, Inc., Cromwell, Conn. A 3 per cent DDT dust (Gesarol A-3 Dust), having talc as a carrier, was applied to the surface of the soil and watered shortly after the application. The soil, especially that in the benches containing the older plants, contained a large amount of organic matter as the beds had been mulched regularly with cow manure. In each treatment the rate of insecticide applied per acre is expressed in active DDT and does not include the carrier.

Named varieties were treated in the months of March and April, 1945, as follows: "Pink Beauty", one to two years old, in plots of 52 square feet each, was treated at the rate of 25, 50 and 87.2 pounds of DDT per acre. Young stock in 12 square feet of bench area, of the variety "Better Times", planted three weeks, was treated with DDT at the rate of 25 pounds per acre. A total of 33 square feet of "Better Times", two to three years old, in plots of 25 square feet each, was treated at the rate of 10, 15, 20 and 25 pounds per acre, while other plots consisting of 50 square feet of bench area received 50 and 87.2 pounds per acre. The variety "Starlight", two to three years old, in plots of 52 square feet each, was treated with 10, 15, 20, 25, 50 and 87.2 pounds of DDT per acre. "Pink Delight", two to three years old, in plots of 25 square feet, was treated at the rate of 10, 15, 20, 25 and 50 pounds per acre. In each case all of the plants, when compared with the untreated control plants, grew and flowered normally.

A METHOD OF APPLYING MILKY DISEASE SPORE DUST

R. L. Beard

For the artificial dissemination of milky disease among Japanese beetle larvae, spores of *Bacillus popilliae* Dutky are incorporated in a talc dust mixture as developed by the Bureau of Entomology and Plant Quarantine and described by White and Dutky (1940, 1942) and Dutky (1942). When this spore dust is applied on turf areas containing heavy populations of Japanese beetle larvae, the disease, under favorable conditions, may become a major factor of control. One disadvantage of this means of control is its slowness of action. Under Connecticut conditions, satisfactory reductions of larval populations by milky disease are rarely observed in less than three years. One factor contributing to this slow action is believed to be that the spore dust, being insoluble, may remain on the surface of the ground for long periods, particularly during the absence of rains, and the bacteria are thus not carried down to the feeding level of the grubs. Moreover, when the spores remain on the surface of the soil, they must be subject to the deleterious effects of ultra-violet light, even though they are partially protected by blades of grass or particles of talc.

For the purpose of shortening the time that spores would remain on the soil surface after application, attention was directed toward processing the spores in a soluble carrier so that soil moisture, dew, or certainly rainfall, would release the spores into the soil as quickly as possible. It was further felt that for ease in handling, such a soluble preparation could be put in tablet form. By incorporating a heavy concentration of spores in the product, each tablet could serve for each spot treatment, which is, as commonly practised, 200,000,000 spores per spot (2 grams of spore dust). In application, the tablet could be dropped in the desired spot, or being soluble, could be dissolved in water and applied as a water suspension of spores for even more prompt introduction into the soil.

A satisfactory spore tablet has been developed which can be prepared in the following manner:[1] In the absence of suitable culturing methods, beetle grubs infected with the mature spore forms of *Bacillus popilliae* must serve as the source of spores. Diseased grubs are ground up in a meat chopper or mortar and pestle, to release the spores. The macerated material is then washed through a fine screen to remove the coarser particles, then through bolting cloth, and finally through coarse filter paper. With adequate washing, a relatively small number of spores are lost in the filtering process, and the filtrate contains an unobjectionable amount of foreign matter. If facilities are available, it is desirable to centrifuge the filtrate at once. Otherwise, the filtrate can be placed in a settling tower and refrigerated. In either case, when the spores settle to the bottom of the tower or centrifuge tube, the supernatant fluid can be decanted, leaving a paste of almost pure spores. It is not necessary, nor desirable, to dry the spores further at this point as they should be moist when added to the carrier.

The choice of carrier or carriers is somewhat limited, for although it should be soluble, it should not be so hygroscopic that it will not function well in the tablet-making machine. It must be non-toxic to the bacteria. Its physical nature must be such as to permit granulation, as a powder does not feed well in the machine, and it must be sufficiently adhesive to press well. While cost would be an item in commercial work, this method of processing permits such high concentration of spores per unit volume of carrier that a material of higher cost is permissible than where bulk quantities are used as with the dust mixtures.

The carrier that has seemed to work well is a mixture of dextrose and sodium bicarbonate. Dextrose by itself is too hygroscopic to make a good tablet. Also, tablets made of this alone are attractive to ants. Although this might be an advantage in breaking up the tablet

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[1] The writer is indebted to Mr. Lawrence Nolan for helpful advice and assistance in formulating the tablets.

rapidly, it is believed that the ants might carry the spores too deeply into the soil to be effective against grubs. Sodium bicarbonate by itself forms a good tablet, but it is less soluble than dextrose. Even though tablets containing sodium bicarbonate dissolve more slowly than those containing dextrose alone, they do crumble and break down in the presence of moisture more rapidly. A mixture of approximately 60 per cent sodium bicarbonate and 40 per cent dextrose seems to form a satisfactory tablet. Undoubtedly, there are other soluble materials that would serve equally well.

The spore "paste" can be added to a reasonably small quantity of the carrier and thoroughly mixed. The quantity of carrier used should be sufficient to take up any excess water, and the result should be a moist, uniform mass. This is then dried in a desiccator. The spore content of the mixture can then be determined by dissolving a given quantity of the mixture, expressed in terms of dry weight, in a known volume of water and counting the spores in a counting chamber according to the usual technique. More of the carrier is then added to the mixture to bring it to the desired dilution. A small amount of moisture is added to the mixture to form an adhering, but friable, material. This is necessary in order to insure a homogeneous preparation instead of an admixture of the three separate components. To granulate, the moist material is then sifted through a wire screen of 24 mesh or finer, and spread as thinly as convenient on a flat container and dried in a desiccator. Heat, of course, cannot be used for drying. It is advisable to stir the material from time to time while drying to prevent the formation of lumps. Also, care should be taken so that the material is not reduced to a powder. For satisfactory results, it is essential that a granular material of uniform particle size and thoroughly dry be obtained. It can then be pressed into tablets in a tablet-making machine. The size of the tablet can be adjusted, by considering the concentration of the spores in the mixture, to contain the desired number of spores.

One disadvantage of this method is that the tablets are not strictly uniform due to the nature of the pressing process. Variation is minimized when the preparation has been thoroughly mixed and is of uniform particle size, but some variation is probably unavoidable. This is not a serious matter when numbers of tablets are used, as the average is maintained, but in an individual tablet, there is always the possibility of there being an excess or a shortage of spores when compared with any other tablet. For field application this would not be serious, as undoubtedly the individual spot treatments of dust vary as much as would the tablets, but for laboratory testing, the variation in tablets should be kept in mind.

Spore tablets prepared as described accomplish very well the purpose of getting the spores into the soil promptly. A tablet placed on the surface of the ground will normally disappear within two or three days even when no rain has fallen. Soil moisture and dew are adequate to break down the material. When rain is falling, a tablet will disappear within a matter of hours. On the other hand, spore dust may remain in sight for weeks, or even months, even when some rain has fallen.

Experience has shown that it is difficult to compare the potency of spores prepared in tablet form with those prepared in dust form and those unprocessed. A critical test could be made only if a given lot of spores was divided into three portions—one to be tested without preparation, one made into tablets and tested, and the third portion made into dust and tested. This has not been possible in the writer's laboratory.

Certain tests have been made which, in general, indicate that the potency of spores in tablets is about equal to those in dust preparations. In one such test, dosages of 1,200,000,000, 600,000,000, and 300,000,000 spores were each added to 70 cubic inches of soil. In one series, spore dust (supplied by the Bureau of Entomology and Plant Quarantine) was used and, in another series, spore tablets were used. In each sample, 40 cc. of water were used to aid in distributing the spores. Each sample was thoroughly mixed in a small barrel-type mixer. Forty grubs were then added to each sample and incubated for 17 days at a temperature of 78° F. Added grass seed provided food for the grubs. The resulting incidence of disease was as follows:

	Per cent of grubs diseased	
Spore dose	Tablets	Spore dust
1,200,000,000	15.2	11.5
600,000,000	2.7	3.6
300,000,000	0	0

In both cases the incidence of disease was less than expected, but clearly there is little difference between the two groups.

In another test, two groups of 100 grubs, each in 100 cubic inches of soil, were placed in boxes. On top of the soil in one box, one tablet, containing an estimated 150,000,000 spores, was centrally placed. In the other box, similarly placed, was spore dust containing an equivalent number of spores. Grass seed was added to provide food, and the grubs were incubated as before. In this test, at the end of 17 days, 41 per cent of the grubs were diseased in the box containing the tablet, and 8 per cent of the grubs were diseased in the box containing the spore dust.

In another test, made in the same way but using a probable 200,000,000 spores in dust form and an estimated 155,000,000 spores in tablet form, the order of results was reversed. Twenty-two per cent of the grubs were diseased in the box containing spore dust, while 9 per cent were diseased in the box containing the tablet. In this case the lower dosage may have been partly responsible for a lower incidence of disease in the box containing the tablet, but also the spores may have had lower potency.

One batch of tablets indicated reduced potency, but this was definitely due to the low potency of the spores that were processed and not to the processing itself. In this case a portion of the spores were not processed, and tests made on these indicated the same low infectivity as shown by the spores processed into tablets.

Another batch of tablets yielded poor results, but no unprocessed spores of this lot were saved for comparison. In this case the low potency may have been due to the preparation, for the original formulation of carrier was not satisfactory for tablet making, and the material was modified and reprocessed several times.

The potency of the spores has not been tested for each stage of the tablet-making process, but spores in the dried granular material ready for pressing into tablets showed a negligible loss of infectivity as compared with the spores from the same source, but not mixed with any carrier. This check was made by injecting grubs with the spores in question.

During the time the tablet is actually dissolving, the contained spores are practically in a syrup and might be subject to great osmotic forces. To check on the possible effect of osmosis on spore potency, a tablet was placed in a test tube and moistened with a drop or two of water. The tablet did not completely dissolve, but it did break down to a very viscous drop. After nine days in this condition, the spores were further diluted and, in a dosage series, injected into grubs. Forty grubs were used for each dosage. These were incubated for two weeks, with the resulting incidence of disease being as follows:

Spore dosage	Per cent of grubs diseased
19,000	100
9,000	88
5,000	83
2,300	74
0	0

This indicated a high potency of the spores, in fact higher than was observed in a group of grubs similarly injected with unprocessed spores from another source.

Although the tests on the spore tablet product have not been exhaustive, it seems reasonable to conclude that spores of *B. popilliae* processed in this way provide a satisfactory means of introducing milky disease among a population of Japanese beetle grubs.

The only functional advantage of such a product over the spore dust seems to be in the fact that the soluble tablet breaks down promptly, presumably allowing the spores to become incorporated in the soil more rapidly than the dust.

As a matter of convenience, the tablet seems to offer a number of advantages. In use, a tablet can be dropped more easily than putting out a measured dose of dust. If desired, the tablets could be dissolved in water, and the spore suspensions applied to the soil. In packaging and handling, tablets make a neater product than dust. If the tablets are made up to weigh about 200 milligrams, each containing 200,000,000 spores, one pound (2,265 tablets) would be equivalent to ten pounds of dust. In preparation, this would mean handling much less bulk of material. The writer has made tablets only on a laboratory scale, but there seems no reason why larger quantities cannot be prepared with equal facility. Aside from the tablet-making machine, and possibly a centrifuge, no special equipment is necessary for putting up the spores in this form.

The terms of U. S. Letters Patent No. 2,258,319, issued to the Secretary of Agriculture, which regulates the use of milky disease spore dust, are very broad and might be interpreted to cover such a bacterial product as the tablets described in this paper.

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THE EFFECT OF TEMPERATURE UPON THE CONTROL OF THIRD INSTAR JAPANESE BEETLE LARVAE IN SOIL TREATED WITH LEAD ARSENATE

J. Peter Johnson

In Connecticut, lead arsenate is usually applied to turf, at the rate of 10 pounds to 1,000 square feet of area, to control larvae of the Japanese beetle. The treatment usually is effective for a period of three to five years. It has been the practice of many to delay the application of the insecticide until the turf is seriously threatened or damaged. As a result, lead arsenate has been applied at all times during the year with the possible exception of the winter months when the ground is frozen. Seasonal differences at the various times of application, therefore, have caused questions to arise concerning the influence of soil temperature upon control expectancy.

A study of the influence of temperature was made in 1941-1942 by treating soil with known amounts of lead arsenate, infesting the treated soil with third instar (nearly full grown) larvae and subjecting the material to different constant temperature levels, 57°, 67°, 77° and 87° Fahrenheit. The minimum of 57° F. was chosen because larval activity lessens below 60° F., and the maximum of 87° F. because it was above the usual mean soil temperature which occurs while the larvae are most prevalent. A constant temperature chamber, with a variation of ± 1° F., was used for each temperature level.

The soil used was a Wethersfield loam with the following composition[1]:

[1] All the soil analyses were made by the Soils Department of the Connecticut Agricultural Experiment Station.

Per cent total N	.1485%	Exch. K	74.8 p. p. m.	Per cent total sand	56.4%
C/N ratio[1]	12.4 to 1	Exch. Ca	1732 p. p. m.	Per cent total silt	34.4%
Carbon	1.852%	Exch. Mg	60.06 p. p. m.	Per cent total clay	9.2%
Per cent total P	.062%	Exch. H	2.1 M. E.[2] 100 gms.	pH	5.93
Available P	89.6 p.p.m.	B. E. C.[3]	8.8 M. E. 100 gms.	Moisture Equiv.	17.36%

Six samples of soil were taken in the field to determine the natural volume weight. Each sample consisted of a soil plug 250 c. c. in volume from which the turf had been removed. The average natural volume weight of the samples was 346 grams, while the dry weight was 290 grams.

Bulk soil for use in the experiment was obtained from the field and air-dried until friable. It was then screened to remove the stones and prepare it for weighing. Sufficient water was added to the soil used in each experimental unit so it contained a moisture content of 19.36 per cent, which was equivalent to that of its natural volume weight. Each test required 24 standard, four-inch, clay flower pots, each containing 692 grams of soil tamped and compressed into a cubic area of 500 c. c.

Lead arsenate was used at the rate of 5, 10, 20 and 40 pounds to 1,000 square feet of surface area mixed to a depth of three inches, or 218, 436, 872 and 1,744 pounds respectively to a three-inch acre. These rates of application were reduced to a cubic inch basis to determine the amounts required for mixing in the soil. For example, since each pot contained 500 c. c. or 30.51 cubic inches of soil, the amount of lead arsenate needed per pot at the 10-pound rate was 30.51 x 0.0105, or 0.32 grams.

The lead arsenate and soil required for a complete temperature series at each concentration was uniformly mixed on a concrete floor by turning and mixing 12 times with a sand shovel. As the relative weight of the lead arsenate in each mixture was exceedingly small, it was disregarded when weighing the material for the individual pots. The pots were then placed in the temperature chambers for 24 hours before infesting with third-instar larvae. Four holes 1½ inches in depth and ¼ inch in diameter were punched in the soil of each pot, each hole infested with one larva and covered with soil.

Loss of soil moisture through evaporation was corrected by weighing all pots three times a week at the 87° and 77° F. temperature levels and twice a week at the 67° and 57° F. levels and adding sufficient water to restore the moisture content to approximately 19 per cent. Larval mortality was recorded after 3½ and seven days and then at weekly intervals until all larvae in the treated soil were dead. After each examination, the soil was immediately replaced in the pot, tamped and compressed as before, reinfested with the surviving larvae, and returned to the temperature chamber.

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[1] C/N Ratio = Carbon Nitrogen Ratio.
[2] M. E. = Millegram Equivalent.
[3] B. E. C. = Base Exchange Capacity.

The results are given in Table 24.

TABLE 24. MORTALITY OF THIRD INSTAR JAPANESE BEETLE LARVAE IN SOIL TREATED WITH LEAD ARSENATE AND MAINTAINED AT TEMPERATURES OF 87°, 77°, 67° AND 57° F.

	87° F.					77° F.					67° F.					57° F.			
		Pounds					Pounds					Pounds					Pounds		
Days	Check	5	10	20	40	Check	5	10	20	40	Check	5	10	20	40	Check	10	20	40
	Number dead					Number dead					Number dead					Number dead			
3½	5	5	13	33	62	5	10	6	19	47	8	4	10	15	12	2	0	1	0
7	2	1	2	18	23	1	8	4	37	45	1	0	1	7	16	3	4	3	3
14	5	3	13	22	4	0	6	12	13	1	2	7	7	30	58	1	3	2	17
21	4	11	29	17	7	3	5	12	15	1	0	5	8	15	5	1	3	9	45
28	8	25	32	6		9	21	26	6	0	0	5	11	11	3	0	5	18	28
35	11	17	6			11	11	21	6	2	2	10	13	6	1	3	3	18	0
42	16	9	0			15	11	13			4	6	9	5	0	0	3	5	1
49	16	11	1			9	9	0			6	3	10	5	1	0	4	10	2
56	9	8				6	5	1			3	9	9	0		7	3	8	
63	9	2				11	5	1			12	8	8	0		2	3	4	
70	4	2				4	5				6	7	2	2		8	11	4	
77	2	1									6	1	3			2	16	3	
84	1	1									6	8	2			2	14	2	
91											7	4	1			15	7	3	
98											4	4	1			0	5	2	
105											7	5	0			3	5	0	
112											4	4	0			2	2	1	
119											4	1	1			6	2	1	
126											4	3				8	1	0	
133											2	1				3	1	1	
140											5	1				11	1	0	
147																3		0	
154																2		1	
Totals	92	96	96	96	96	74	96	96	96	96	93	96	96	96	96	84	96	96	96

The frequencies in each column of Table 24 were transformed to cumulated percentage frequencies and these, in turn, to probits (1). The probits were plotted against the logarithm of the length of survival time in days. The expected time (in logs) required to kill given proportions of larvae (in probits) was interpolated at each dosage of lead arsenate and temperature. When the interpolated log-times at each temperature were related to the log-dose, approximately parallel dosage-response curves were obtained at the 65, 75, 85 and 90 per cent levels of mortality. The series at the 85 per cent level was slightly steeper and the interpolated results are given in Table 25 after converting from logs to days.

TABLE 25. EXPOSURE TIME IN DAYS FOR 85 PER CENT MORTALITY OF THIRD INSTAR LARVAE

	Pounds of lead arsenate			
Temp.	5	10	20	40
57° F.		93.5	67.7	26.9
67° F.	95.5	58.9	30.9	14.1
77° F.	54.9	35.4	18.6	5.6
87° F.	46.7	26.9	16.2	6.1

The values which have been changed in original units in Table 25 have been plotted against the log-dose in pounds (Figure 16). The interpolated points for each temperature were fitted with parallel lines by the method of least squares.

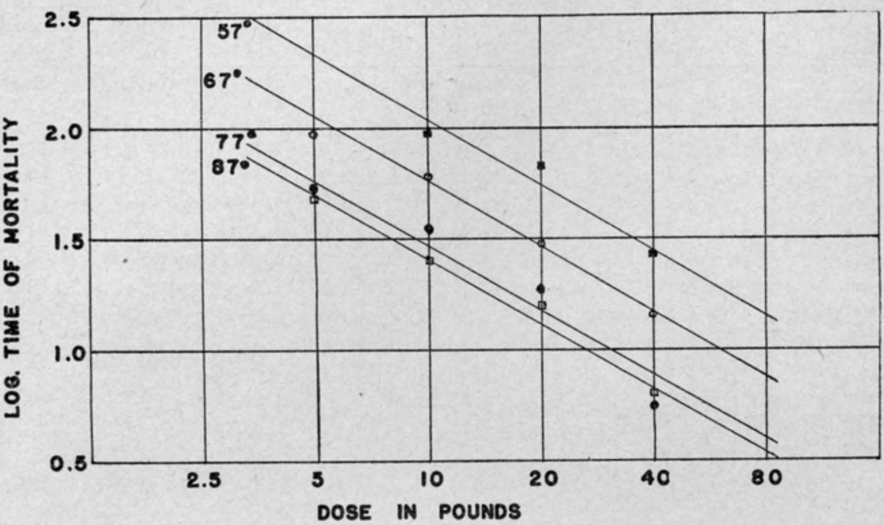

Figure 16. Relation of exposure time, in logarithms, necessary to kill 85 per cent of the larvae to dose of lead arsenate per 1000 square feet, at different temperatures in degrees Fahrenheit.

The results obtained agree in the main with those obtained by Fleming (2). The differences were caused primarily by the different techniques and temperatures used.

Conclusions

At the temperatures tested, the logarithm of the lethal dose of lead arsenate varied inversely with the logarithm of exposure time.

For any given length of treatment, the amount of lead arsenate required to kill 75 per cent of the larvae at 67° F. was twice that needed at 77° F. Likewise, twice the amount was required at 57° F. as at 67° F. Between 77° F. and 87° F. there was little difference in the necessary dosage for the same length of treatment.

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EXPERIMENTAL CONTROL OF ORCHARD INSECTS

PHILIP GARMAN

Experiments in fruit insect control during 1945 were designed to answer some of the many problems facing Connecticut growers. Work with DDT on apples, peaches, quinces and pears included tests with supplements for European red mite control, as well as control of the oriental fruit moth, quince curculio, seventeen-year locust, pear psylla and apple maggot. General conclusions after two years' work are as follows: DDT is a good insecticide which will be useful, certainly on quinces, probably on peaches, possibly on apples, and probably not at all on pears. The very good control of codling moth obtained by other workers indicates at least that it may be used on apples in emergencies such as developed this year. The main factors operating against its speedy adoption for apples lies in negative red mite, poor curculio and the, as yet, doubtful maggot control (Table 32). Its use on quinces appears desirable (Table 35) as soon as the material is commercially available. For peaches, our experiments indicate that it is promising for the oriental fruit moth. It is known to be destructive to parasites, but there is no reason why successful schedules cannot be devised to give maximum protection with minimum destruction of parasites.

Apples

Continued experimentation with heavy-dose, reduced schedules gave promising results for Baldwin, Rome and Delicious (Tables 26, 27, 28), but results were not entirely satisfactory for McIntosh (Tables 29, 30), Duchess or Staymen Winesap. Increasing the fungicide from 1.5 to three pounds per 100 gallons gave an increase in protection from scab, as might be expected, but an increase in lead ar-

TABLE 26. CONTROL OF APPLE PESTS WITH REDUCED SPRAYS. 1945
Burton Orchard
Baldwin

	Treatment Amounts in lbs. per 100 gals.				Per cent free of insect and disease blemishes	Per cent severe russet
	Lead arsenate	Fermate	Bentonite	Veegum[1]		
(1)	6	1½	2	..	97.25	7.85
(2)	9	1½	2	..	96.39	7.71
(3)	6	1½	..	5	94.46	5.71
(4)	9	1½	..	5	95.93	16.88
(5)	6	3	2	..	95.09	5.01
(6)	9	3	2	..	98.11	9.35
(7)	6	3	..	5	97.15	15.11
(8)	9	3	..	5	95.62	7.90

Spray dates: April 12-13, April 30, May 22. Maggot dust: July 30.
½ lb. skim milk powder added to all treatments.

[1] Trade name for aluminum magnesium silicate gel.

Notes: (1) Disease and insect control satisfactory.
(2) Differences in amount of russetting not significant.
(3) One and one-half pounds Fermate to 100 gallons is ample for this orchard.
(4) Six pounds of lead arsenate is sufficient for the insects present in 1945.

TABLE 27. GENERAL PEST CONTROL WITH REDUCED SPRAYS. 1945
Westwoods
Romes

Treatment, lbs. in 100 gals.		Tree	Per cent clean externally	Per cent maggot	Per cent curculio	Per cent scab
Lead arsenate	6 lbs.	J 20	81.65	5.39	.77	10.95
Fermate	1½ lbs.					
Skim milk	½ lb.	J 21	92.51	7.90	.06	4.79
White oil	2 qts.					
Veegum	5 lbs.	J 22	87.98	20.41	.83	6.63
Nicotine sulfate	1 pt. in first spray					
Lead arsenate	6 lbs.	J 27	89.96	6.78	.00	5.02
Bentonite	3 lbs.					
Skim milk	½ lb.	J 29	94.59	9.82	.05	5.36
White oil	2 qts.					
Fermate	1½ lbs.					
Nicotine sulfate	1 pt. in first spray					
	Average		89.34	10.06	.034	6.55

Spray dates: April 13-14, May 2, May 24, June 7.

TABLE 28. CONTROL OF APPLE PESTS WITH REDUCED SPRAYS. 1945
Burton Orchard
Delicious

Treatment Amounts in lbs. per 100 gals.						
Lead arsenate	Fermate	Bentonite	Veegum	Skim milk	Per cent clean	Per cent scab
6	1½	..	5	½	94.40	2.17
6	1½	2	..	½	94.31	.59

Spray dates: April 12-13, April 30, May 22. Maggot dust: July 30.

Notes: (1) Little or no russet apparent on examination.
(2) Disease and insect control satisfactory.

senate from six to nine pounds per 100 gallons reduced the effectiveness of the mixture. However, with the best treatments, 73 per cent of the trees yielded 85 per cent clean fruit or better. Maggot control was satisfactory in the Burton orchard where a late July dust was applied, but it was not entirely satisfactory on all varieties in the more heavily infested Westwoods orchard where no such late treatment was given. This year was wet throughout the summer, and both scab and apple maggot were problems in the experimental blocks.

A few dormant scale control tests in Westwoods gave good scale reduction with various commercial oils, plus nicotine sulfate or DN[1] solution. These tests, made at the green tip stage of development, later than commonly recommended for DN, caused some bud scorch where DN and oil were used in combination, but none where the materials were applied separately or when oil was combined with nico-

[1] Dinitro-o-cresol.

TABLE 29. CONTROL OF APPLE PESTS WITH REDUCED SPRAYS. 1945
Burton Orchard
McIntosh

	Treatment Amounts in lbs. per 100 gals.					
	Lead arsenate	Fermate	Bentonite	Veegum	Per cent clean	Per cent scab
(1)	6	1½	2	..	78.79	19.81
(2)	9	1½	2	..	52.76	46.07
(3)	6	1½	..	5	59.09	40.02
(4)	9	1½	..	5	61.10	37.80
(5)	6	3	2	..	85.23	13.77
(6)	9	3	2	..	81.29	17.21
(7)	6	3	..	5	89.53	7.78
(8)	9	3	..	5	60.49	38.43

Spray dates: April 12-13, April 30, May 22. Maggot dust: July 30.
½ lb. skim milk powder added to all treatments.

Notes: (1) Scab control unsatisfactory.
(2) Scab control better with 3 lbs. Fermate to 100 gals. compared with 1½.
(3) Scab control slightly better with bentonite.
(4) Scab control better where 6 lbs. lead arsenate was used instead of 9.
(5) 19 trees out of 26 (or 73%) receiving 3 lbs. Fermate per 100 gals. were above 85% in clean fruit.
(6) 9 trees out of 27 (or 33%) receiving 1½ lbs. Fermate per 100 gals. were above 85% in clean fruit.

TABLE 30. GENERAL PEST CONTROL WITH REDUCED SPRAYS. 1945
Westwoods
McIntosh

Treatment, lbs. in 100 gals.		Tree	Per cent clean externally	Per cent scab	Per cent curculio	Per cent maggot[1]
Lead arsenate	6 lbs.	H 20	51.82	42.91	.81	9.0
Fermate	1½ lbs.	I 16	69.13	27.86	.90	0.0
Skim milk	½ lb.	K 19	73.53	23.52	.00	12.0
White oil	2 qts.	M 14	73.25	24.25	.00	0.0
Veegum	5 lbs.	O 16	68.18	29.87	1.30	11.1
Nicotine sulfate	1 pt. in first spray					
	Average		67.18	29.68	.60	6.4
Lead arsenate	6 lbs.	M 26	86.00	13.88	.00	6.0
Bentonite	3 lbs.	K 25	57.73	41.15	.00	15.0
Skim milk	½ lb.	J 25	82.42	15.12	.70	0.0
White oil	2 qts.	J 23	77.84	20.24	1.80	9.6
Fermate	1½ lbs.	J 33	80.79	15.23	.00	0.0
Nicotine sulfate	1 pt. in first spray					
	Average		76.96	23.90	.50	7.8

Spray dates: April 13-14, May 2, May 24, June 7.

[1] Drop counts only. Picked counts average about half these figures.

tine sulfate. A commercial miscible oil plus two quarts of DN solution was particularly effective in reducing the infestation.

A cooperative experiment with Doctor Kerr of the United States Rubber Company, Naugatuck Chemical Division, gave promising results for red mite control where DDT was used as the insecticide. The experiment did not begin to show results this year until after

TABLE 31. EUROPEAN RED MITE CONTROL ON APPLES. 1945

Varieties — Baldwin, Rome

Materials and concentration	Variety	Adult females per 20 leaves Aug. 11	Aug. 18	Aug. 27
(1) DDT plus "72 E"	Rome	88	178	265
(2) DDT in talc	Rome	226	679	572
(3) Same as (1)	Baldwin	87	207	266
(4) Same as (2)	Baldwin	484	918	676
(5) DDT plus "72 E"	Rome	29	50	81
(6) DDT in talc	Rome	376	481	297
(7) Same as (5)	Baldwin	46	89	103
(8) Same as (6)	Baldwin	158	566	549
Totals for DDT–"72 E"		250	524	715
Totals for DDT–talc		1,164	2,644	2,094

Explanation of treatments: Amounts per 100 gals.

(1) "72 E" containing 33 1/3% DDT 1 qt., plus flotation sulfur 8 lbs.

(2) DDT-talc containing 33 1/3% DDT 2.32 lbs., plus flotation sulfur 8 lbs.

(5) "72 E" 1 pt., plus flotation sulfur 8 lbs.

(6) DDT-talc 1.16 lbs., flotation sulfur 8 lbs.

Applications: April 14, May 5, 16, 26, June 9, 25-26, July 6, 26. Power sprayer —6 nozzle boom.

TABLE 32. EXPERIMENTS WITH MAGGOT CONTROL. 1945

Westwoods — Cortlands

DDT Dusts

Tree		Per cent maggoty 1943	1944	1945
B 2	Drops		13.5	95.09
	Picked	100	9.5	58.00
B 5	Drops	100	7.3	88.27
	Picked		5.6	38.00
B 9	Drops		20.7	50.0
	Picked	100	12.7	20.0
B 13	Drops	98	31.6	83.52
	Picked		17.0	38.00
B 17	Drops		14.4	71.69
	Picked	93	24.7	46.79

Treatments for maggot control:

1943 — None

1944 — Dusted with 3% DDT in talc July 3, 17, 28, August 10.

1945 — Dusted with 5% DDT in talc July 6, 26, August 8.

Notes: 1945—Dusts either not frequent enough or late enough. Rainy season, with flies coming in late.

1944—A light season for maggot, and dry.

August 1. At that time, comparisons of blocks treated with DDT and talc, and the same concentration of DDT with the special agent "72 E"[1] gave results distinctly in favor of the latter (Table 31). A pronounced difference in tree color was also noticeable between the two treatments about August 15.

A continuation of last year's tests with DDT dust for maggot control on Cortlands was disappointing. Last year, substantial control appeared to be obtained with four 3 per cent talc, DDT dusts, but three 5 per cent dusts applied this year were not nearly as successful (Table 32).

Peaches

Experiments in the Mount Carmel peach orchard showed the desirability of using basic lead arsenate plus wettable sulfur in early sprays against the plum curculio. The combination of early arsenate and late DDT applications in dust form was particularly gratifying in the production of a large amount of clean fruit (Tables 33, 34).

Quinces

In the quince planting, control of both quince curculio and oriental fruit moth, as well as fruit spot diseases, was obtained with a combination of oil, Fermate and DDT, the oil being emulsified with skim milk powder. Another preparation containing DDT dissolved in Velsicol[2] and emulsified with skim milk powder gave satisfactory insect control, but did not affect the fruit spot. A combination of lead arsenate and DDT was no more effective than DDT alone (Table 35).

TABLE 33. ORIENTAL FRUIT MOTH CONTROL IN ELBERTA PEACHES. 1945
Mount Carmel

Treatment	Per cent fruit moth	Number of trees examined
(1) Sulfur-oil dust (R. & H.) (no DDT)	13.56	8
(2) Niagara sulfur-oil-DDT dust (3% DDT)	7.20	9
(3) Sulfur + 5% DDT fused dust (no oil)	3.44	12
(4) Sulfur + 5% DDT mixed dust (no oil)	1.48	7
(5) Check – no dust for fruit moth	10.95	11

Dates of dust applications: July 11-12, August 9. Plot No. 1 received a third dusting on August 30. Remaining plots not treated on that date.

[1] An iso amylnaphthyl ether.

[2] Methyl naphthalene.

TABLE 34. PEACHES. CLEAN FRUIT ESTIMATES. 1945

Mount Carmel
Elbertas

Treatment	Tree	Total fruits on tree	Clean	Per cent clean
Basic lead arsenate 2 lbs.; flotation sulfur 8 lbs.; lime 16 lbs. – 100 gals. – 2 sprays 5% DDT-sulfur. Mixed dust, 2 applications	H 3	222	216	97.29
Same as above	H 4	199	190	95.47
Basic lead arsenate 4 lbs.; flotation sulfur 8 lbs.; lime 4 lbs. – 100 gallons – 2 sprays 5% DDT-sulfur. Mixed dust, 2 applications	D 3	452	380	84.07
Same as above	D 4	905	851	94.03
Same as above	A 15	588	535	90.98
Same as above	A 16	639	568	88.88
Totals		3,005	2,740	91.18
Flotation sulfur 8 lbs.; lime 4 lbs.; – 100 gallons – 2 sprays No late dusts	D 8	552	429	77.71
Flotation sulfur 8 lbs. – 100 gals. – 2 sprays Sulfur-oil dusts – 2 late applications	C 7	311	241	77.49
No early sprays 5% DDT-sulfur – 2 applications	E 9	665	496	74.59
Same as above	E 12	536	300	55.97
No early sprays Sulfur-oil dusts – 2 applications	B 2	350	124	35.43
Same as above	B 3	343	120	34.99
Fermate 1½ lbs.; lime 1½ lbs. –2 sprays early No late dusts	H 21	308	106	34.42
Same as above	H 22	476	174	36.55
Totals		3,541	1,990	56.20

TABLE 35. CONTROL OF QUINCE INSECTS. 1945
Percentages of Wormy Fruit from Trees Receiving Four Different Treatments.

(1) Tree	(1) Per cent	(2) Tree	(2) Per cent	(3) Tree	(3) Per cent	(4) Tree	(4) Per cent	(5) Tree	(5) Per cent
A 1	0.00	A 7	22.22	A 5	0.00	A 4	51.51	A 9	100.00
A 2	17.64	A 8	18.18	A 6	2.86	A 11	37.50	A 10	80.00
A 13	1.43	A 17	20.58	A 16	28.78	A 12	50.00	A 19	67.27
A 14	4.85	A 18	11.11					A 23	100.00
A 21	7.05								
A 22	5.71								
B 11	8.59	B 3	25.00	B 5	9.09	B 2	37.50	B 7	64.29
B 12	5.71	B 4	8.11	B 6	24.59	B 15	31.13	B 8	76.00
		B 9	23.72	B 13	16.67	B 16	47.47	B 17	100.00
		B 10	19.64	B 14	23.58			B 18	94.10
		B 20	29.14	B 23	28.57				
Av.	7.05		19.05		19.96		41.89		84.22

Explanation of treatments:

Materials and amounts per 100 gallons.

(1) DDT (25%) 6 lbs., Fermate 1½ lbs., skim milk powder ½ lb., white mineral oil ½ gallon. Spray dates: June 7, July 7, August 10.

(2) DDT (25%) 3 lbs., lead arsenate 3 lbs., skim milk powder ½ lb., Fermate 1½ lbs., white mineral oil ½ gal. (omitted from last spray), Veegum 5 lbs. Spray dates: June 7, July 7, August 10.

(3) DDT (pure) 1 lb., Velsicol solvent 1 qt., skim milk powder ½ lb. Spray dates: June 7, July 7, August 10.

(4) Lead arsenate 6 lbs., Fermate 1½ lbs., skim milk powder ½ lb., Veegum 5 lbs., white mineral oil ½ gal. (omitted from last spray). Spray dates: June 7, July 7, August 10.

(5) Check, no treatment.

Pears

In a cooperative test with the United States Bureau of Entomology and Plant Quarantine, it was shown (Table 36) that pear psylla adults could be destroyed effectively in October with nicotine alkaloid dissolved in kerosene and atomized onto the trees with special blowers. A solution of one pint alkaloid per gallon of oil applied at the rate of five to 10 ounces per tree gave 95 per cent kill in a number of separate tests. The material was also atomized in the air stream of a commercial duster under pressure from a small paint sprayer. Results were equally good. The plan of this experiment consisted of spraying, then counting the psylla dropped on five paper pie plates placed underneath the trees; blowing the trees without spray to dislodge those killed by the first spray but not falling to the ground, then respraying the trees with 32 ounces per gallon of kerosene, a dose which removes 98 per cent (for practical purposes here considered as 100 per cent) of those remaining. The population on the tree at the beginning of the experiment is then estimated by simple addition.

It was also learned in the course of these experiments that 3 per cent nicotine dust was much more effective for killing adult psylla than 5 per cent DDT and that the spray treatments of nicotine alkaloid in kerosene destroyed a large percentage of fifth instar nymphs. There also appears to be a distinct fumigation effect by the volatile nicotine which does not have to come into direct contact with the adult psylla to kill them.

Dr. D. W. Hamilton, K. A. Haynes, William Holland and John Smith cooperated and were responsible for most of the work involved. Thanks are also due to the owner, A. T. Henry, for the use of the orchard, and to his son, David, who operated the tractor throughout these tests.

TABLE 36. PEAR PSYLLA CONTROL EXPERIMENTS. OCT. 4, 1945
A. T. Henry's Orchard, Wallingford

Oz. alkaloid per gallon	Oz. applied per tree	First knockdown	Second knockdown	Per cent control by first application
Adult knockdown with nicotine alkaloid in water solution plus 20 oz./gal. B 1956 spreader				
2	17.0	617	61	66.8
4	7.4	954	83	69.7
8	1.5	76	99	43.4
16	5.6	159	41	79.50
32	2.3	142	24	85.54
Knockdown with nicotine alkaloid in kerosene solution				
2	7.8	287	25	74.2
4	7.5	421	71	87.5
8	6.5	87	7	92.5
16	8.0	178	5	97.3
32	7.1	277	20	98.6

NOTES ON THE BIOLOGY OF THE CODLING MOTH IN CONNECTICUT

J. F. TOWNSEND

The unusual weather conditions in 1945 apparently spread out the emergence of over-wintered stock over an unusually long period, with low temperatures unfavorable for oviposition by the earlier moths, delay of a large proportion of moths until the more favorable warm weather of late June and July, and the consequent hatching of a large proportion of the first generation larvae at a time later than commonly expected in planning insecticide coverage against this insect in Connecticut. Most of the damage occurred after the first of July, in a period when insecticide coverage had become much reduced in most orchards. The damage was more severe than usual for the State in general, and particularly so in several large commercial orchards.

Late hatching of an important part of first brood larvae has probably been much more frequent than generally realized, having largely escaped notice in commercial orchards in the former periods of low population levels. Examination of past temperature records in the light of seasonal life history studies in Connecticut and nearby regions suggests that hatching of at least one-third of the first generation larvae may have occurred as late as July in 13 out of the last 27 years. More attention to insecticide coverage throughout June and July seems indicated if the insect continues to cause substantial damage.

Several additional factors may have had an important bearing on the codling moth problem. A tendency toward an increase of the insect, resulting from summer temperatures above normal for the past 15 years, is logical to expect from similar experience in the 1870's, before insecticides were commonly used. The overgrown condition of many orchard blocks, following several years of labor shortage, has greatly increased the difficulty of thorough insecticide applications, and in some instances has seemed obviously a factor in the poor control obtained. The purchase of infested apple boxes from the New York market has undoubtedly increased the moth population in certain orchards, particularly in the vicinity of storages. It is feared that some of the introduced moths may have been of strains more resistant to arsenate of lead than the local moths, but nothing is definitely known on the subject.

Satisfactory control with an arsenate of lead schedule was obtained as usual in many orchards, including the two small orchards handled by the Experiment Station. In one commercial orchard under close observation, codling moth damage declined markedly from the higher levels of previous years, following some improvement in general orchard methods, but particularly in the thoroughness of the lead arsenate sprays.

On the question of increased resistance of the insect to lead arsenate in Connecticut, no definite evidence is as yet available to warrant the widespread assumption that such an increase in resistance has occurred. More definite information on the subject seems needed both in the study of the biology of the codling moth and in its control.

COMMERCIAL NURSERY CONTROL OF THE PEACH TREE BORER

Philip P. Wallace[1]

The culling of finished two-year-old peach trees because of peach tree borer infestation observed at the time of digging for sale is one of the most serious economic problems in the commercial propagation of peach trees in the northeastern United States. The loss is seldom less than 20 per cent and often as much as 50 to 60 per cent of the budded stock at two years from seed.

In this section the pits are planted in early spring and the plants are budded in August of the same year. In late spring of the following year the top above the bud is cut off and the bud shoot grows

[1] See footnote 1, page 33.

vigorously so that the plants are generally finished by the end of the second season. They are dug in late fall, stored in packing sheds during the winter, and sold for transplanting the following spring, two years from seed.

Three- to four-month-old seedlings may be attacked by the borer if the local infestation is high, and at this stage the small plants are likely to die or be seriously injured. Most injury of commercial importance, however, results from attack during the early summer of the second season when the plants are about 15 months old, with a bud shoot three feet tall and one-half inch in diameter.

Life History and Habits

The peach tree borer is the larva of a clear-wing moth belonging to a family known as the Aegeriidae, superficially somewhat resembling a large, metallic-blue wasp.

There is one generation a year. Adults first appear in southern Connecticut during the last week of June or the first of July. Although most of the eggs are deposited by the third week in July, adults continue to emerge throughout the summer and some egg laying extends until frost. The eggs are deposited on the surface of the stems and leaves of the peach and are occasionally found on other material close to or on the ground.

As soon as a larva emerges from the egg it travels at once down the stem. At a location generally not more than an inch or two above or below the ground level the larva bores through the bark, and the remainder of its development is passed within the stem or root of the plant.

Infestation is indicated by a heavy, gummy exudation mixed with frass. However, injuries of many kinds may cause a similar exudation and small larvae may not cause enough gum and frass to be readily noticed. So for positive identification it is often necessary to cut away part of the stem, thus ruining the tree for sale regardless of the presence of borers.

Control

A reasonable combination of good management, sanitation, and chemical treatment will entirely eliminate commercial loss from the peach tree borer in nursery plantings.

The most common and obvious source of infestation is the stumps of discarded seedlings which are often neglected in cleaning up and are left or plowed under. The peach tree borer breeds not only in peach but in plum, wild cherry, chokecherry and others of the Prunus group, and the moths sometimes fly a mile to deposit their eggs. It is therefore essential to eradicate permanently all these sources of possible infestation and to isolate and rotate plantings as much as practical.

There are two stages in development when the larvae can be killed, and a different type of chemical treatment is required for each. (1) During the period between emergence of the young larva from the egg and before it enters the trunk, it is susceptible to contact poisons. Nicotine or pyrethrum are excellent contact poisons but the duration of toxicity of these sprays is generally limited to a few hours. However, if a poison with long residual toxicity, such as DDT, is applied, the larva must come in close contact with the toxic deposit while crawling down to the base of the trunk. (2) In late August or early September most of the eggs have been deposited and the borers are established in the trunk near the base of the plant. Soil treatment with the proper fumigant shortly after this will destroy practically all the borers. Unfortunately, the borers may already have caused extensive damage to some of the trees, although the most serious injury occurs when the borers are larger, from the middle of September till the ground freezes and from the first of May until they transform to adult moths in late June.

It has been known for a long time that certain fumigants, particularly paradichlorobenzene and ethylene dichloride, are effective soil treatments for killing peach tree borers. The use of these chemicals on young trees has been tested, and it is known that under certain conditions serious injury may result from using the commonly recommended dosage. The effectiveness of DDT against the peach tree borer on large trees has been indicated but the use of a residual DDT spray for commercial nursery peach plantings has not been reported.

Investigations here have been directed toward determining: (1) a soil fumigant treatment which even under very unfavorable conditions is safe and effective, and (2) the effectiveness of DDT spray treatments for control of the peach tree borer in seedling peaches growing in a commercial nursery.

DDT Spray Tests

DDT, technical grade, was dissolved in Velsicol AR 50 (mono and dimethyl naphthalenes) and emulsified with Emulphor E. L. (a condensation product of ethylene oxide and an organic acid) in water to make a stock emulsion. The spray was applied with a hand pressure tank sprayer having a nozzle opening of .045 inch diameter which gave a narrow spray cone and supplied a large volume at satisfactory pressure. Only the base of the trunk and lower branches were sprayed, although some of the lower leaves were unavoidably wetted. The trees were sprayed from both sides of the row and only one application was made during the season, on June 23 at Ellington.

The peaches were 14 months old, budded in August of the preceding year and had a stock diameter of one-half inch and bud shoot three feet tall, three-eighths inch diameter[1]. In a two-acre field, four plots were chosen at random, each consisting of 49 trees in a row. The first seven trees in each plot received treatment number 1; the next seven, treatment number 2, etc. Seven trees in each of four plots, 28 in all, thus received the same treatment. All trees were dug and examined in early November.

The dosage series applied was based on results of laboratory tests. An emulsion was used because the DDT did not settle and it contained a minimum of material which might be phytotoxic.

The information obtained from these trials (Table 37) indicates that DDT applied as an emulsion in late June at the rate of three pounds per 100 gallons gave effective control of the peach tree borer. At lower concentrations, control was diminished. It appears from these tests that adding bentonite to the mixture increased its effectiveness.

TABLE 37. DDT TREATMENTS FOR CONTROL OF THE PEACH TREE BORER
Each test constitutes 4 replicates of 7 two-year trees
Spray volume: approximately 0.5 oz./tree

Concentration per 100 gals. water	Total trees	No. trees infested	Total borers	Per cent trees infested
¾ lb. DDT	28	4	7	14
¾ lb. DDT + ¾ lb. bentonite	28	1	1	3.5
1½ lbs. DDT	28	1	2	3.5
1½ lbs. DDT + 1½ lbs. bentonite	28	0	0	0
3 lbs. DDT	28	0	0	0
3 lbs. DDT + 3 lbs. bentonite	28	0	0	0
Control	28	10	13	35.7

In the light of many recent reports relating to concentrated DDT sprays (10 to 20 per cent) used to obtain effective residues, it appears that a 0.4 per cent spray, i. e., three pounds per 100 gallons, should leave an entirely ineffective residue. However, the residue obtained was quite effective. One gallon of spray thoroughly covered the trunks of 60 trees, and it is estimated that with the type of nozzle used at least half the spray missed the trunk or ran off. It is estimated that a maximum DDT residue of 450 mg./sq. ft. of trunk surface was deposited and, if the spray loss were much greater, there would still remain a deposit that is known to be lethal for long periods to insects susceptible to DDT poisoning. The fact that both adults and larvae readily succumb to contact with DDT spray deposit was demonstrated in the laboratory.

At the time of these spray applications the weather was favorable for spraying, and no leaf injury was observed here at any time. But,

[1] The Burr Nurseries, Inc., of Manchester, Conn., supplied trees for all tests and assisted with labor.

when another new planting was treated two days later with the same mixtures (except for the addition of a wetting agent), the temperature was 90° F., it was very dry, and a brisk wind blew droplets on many of the leaves. Here, a considerable amount of foliage injury resulted, appearing first as reddish-purple, circular areas which finally turned black, and many leaves dropped.

In these later trials no infestation occurred in any of the plants, although seedling peaches 50 yards away were well infested. It is believed that the controls were too close to the treated plants and that most of the moths which may have approached to deposit eggs were affected by contact with sprayed plants.

The addition of a wetting agent (Nacconal N. R.) at the rate of 2.5 per cent of the DDT solvent by weight greatly improved the wetting properties of the spray and did not cause foaming nor appreciably increase in run-off.

Soil Fumigant Treatments

For the soil treatments, a liquid was preferred because of relative ease of application. Standard ethylene dichloride emulsion and a proprietary paradichlorobenzene emulsion[1] were used. A knapsack sprayer with the nozzle removed served to distribute the material uniformly after a little practice. The operator moved at a constant speed and the dosage was doubled by doubling the number of applications. The liquid was directed at the soil about two inches from the row. The soil temperature was 64° and the air temperature 72° F. Two days previous there had been 1.5 inches of rainfall and a high wind had moved all the trees so that there was a hollow in the soil at the base of the stems. Moreover, the last cultivation had left a ridge eight inches wide and one inch high near the plants. In most cases the spray hit the tree base and the cup-like depression was filled with liquid that was only slowly absorbed into the wet soil. Four hours after treatment 1.0 inch of additional rain fell. These unfavorable conditions provided a rigid test for the treatments.

These results indicate that mounding the trees after treatment with the emulsions did not affect the kill of borers. Injury to tree tissue was considerably less where the trees were mounded. This was probably due to more rapid absorption of the liquid and would not ordinarily be necessary. Ethylene dichloride and paradichlorobenzene emulsions at standard dosages were about equal in borer-killing effectiveness. "Per cent injury" refers to the per cent of the tissue at the base of the trees which was killed by treatment. "0-20" indicates that some of the plants were unaffected while others sustained light to moderate injury of the bark at the base. Injury was, of course, more severe where the bark had been broken. These two-year peach trees were severely injured by ethylene dichloride application, where-

[1] Para-Scalecide.

TABLE 38. PARADICHLOROBENZENE EMULSION TREATMENTS FOR PEACH TREE BORER

Test conditions: Not mounded
Each test constitutes 3 replicates of 8 two-year trees

Dosage	Total trees	Number infested	Per cent infested trees freed	Per cent total trees remaining infested	Total borers	Per cent borers killed	Per cent tree injury
2 oz. 1-15	24	5	80	4.2	5	80	0 – 10
4 oz. 1-15	24	4	100	0	4	100	0 – 10
2 oz. 1-7	24	5	100	0	6	100	0 – 10
4 oz. 1-7	24	5	80	4.2	5	80	0 – 10
8 oz. 1-7	24	6	50	12.5	6	50	0 – 10
Control	24	7	14	25	7	14	0
Total	144	32 (22%)			33		

TABLE 39. PARADICHLOROBENZENE EMULSION TREATMENTS FOR PEACH TREE BORER

Test conditions: Trees mounded
Each test constitutes 5 replicates of 8 two-year trees

Dosage	Total trees	Number infested	Per cent infested trees freed	Per cent total trees remaining infested	Total borers	Per cent borers killed	Per cent tree injury
2 oz. 1-15	40	9	66	7.5	9	66	0
4 oz. 1-15	40	8	87	2.5	8	87	0
2 oz. 1-7	40	6	100	0	6	100	0
4 oz. 1-7	40	12	58	12.5	12	58	0
8 oz. 1-7	40	5	80	2.5	5	80	0 – 10
Control	40	8	0	20	8	0	0
Total	240	48 (20%)			48		

TABLE 40. ETHYLENE DICHLORIDE EMULSION TREATMENTS FOR PEACH TREE BORER

Test conditions: Not mounded
Each test constitutes 8 replicates of 8 two-year trees

Dosage	Total trees	Number infested	Per cent infested trees freed	Per cent total trees remaining infested	Total borers	Per cent borers killed	Per cent tree injury
2 oz. 7.5%	64	14	71	6	16	75	0 – 80
4 oz. 7.5%	..	..	..	..	..	..	....
2 oz. 15%	64	8	100	0	8	100	0 – 100
4 oz. 15%	64	7	100	0	7	100	0 – 100
Control	64	9	22	11	9	22	None
Total	256	38 (15%)			40		

as paradichlorobenzene caused no or inconsequential injury at the highest dosages used.

Although no borer infestation was observed, similar treatments were applied to trees in sample plots of a nearby block of one-year seedling peaches, for the purpose of determining plant tolerance.

TABLE 41. ETHYLENE DICHLORIDE EMULSION TREATMENTS FOR PEACH TREE BORER
Test conditions: Trees mounded
Each test constitutes 5 replicates of 8 two-year trees

Dosage	Total trees	Number infested	Per cent infested trees freed	Per cent total trees remaining infested	Total borers	Per cent borers killed	Per cent tree injury
2 oz. 7.5%	40	11	54	10	14	50	0
4 oz. 7.5%	40	7	86	2.5	7	86	0
2 oz. 15%	40	8	87	2.5	8	87	0 – 20
4 oz. 15%	40	7	71	5	7	71	0 – 100
Control	40	11	0	27.5	11	0	0
Total	200	44 (22%)			47		

TABLE 42. CHEMICAL INJURY TO ONE-YEAR PEACH SEEDLINGS
8 replicates of 8 trees each

Paradichlorobenzene emulsion	
2 oz. 1 – 15	No injury
4 oz. 1 – 15	No injury
2 oz. 1 – 7	No injury
4 oz. 1 – 7	Slight brown flecking in cortex, inconsequential
8 oz. 1 – 7	Slight brown flecking in cortex, inconsequential; Does not appear more extensive than 4 oz. dosage
Ethylene dichloride emulsion	
2 oz. 7.5%	Moderate to severe with some killed roots
4 oz. 7.5%	Severe to dead
2 oz. 15%	All roots dead

Soil conditions and depressions at the tree bases were similar to those described above. All of these trees were mounded three hours after treatment and injury was much more severe than for the two-year trees.

It is apparent that under these conditions ethylene dichloride is unsafe to use on one-year peach trees at a concentration sufficient to give effective peach tree borer control. Paradichlorobenzene emulsion caused only minor injury at the higher dosages.

Discussion

Although this is not a large-scale experiment and is somewhat preliminary in nature, the results attained with DDT emulsions are very promising. A 0.4 per cent emulsion gave excellent control. Whether or not the addition of bentonite improves the mixture remains to be proven. The timing of the application should be more definitely established. There is also the question of possible injury to the trees by the DDT.

The results attained with paradichlorobenzene and ethylene dichloride are not so clear-cut and are subject to the same criticisms as above. Moreover, the latter apparently causes severe injury to young peach trees under some conditions. Neither of these two materials should be condemned on the basis of these experiments alone.

THE CONTROL OF COMSTOCK'S MEALYBUG (*Pseudococcus comstocki* Kuwana) ON TAXUS IN CONNECTICUT

Philip P. Wallace[1]

Comstock's mealybug has been known for several years to occur occasionally on *Taxus* spp. throughout Connecticut, but in the fall of 1944 two serious infestations were observed. Mealybugs were very abundant on large commercial nursery plantings where their feeding had caused loss of foliage and stunting of growth.

The dwarf, close-growing, short-leaved varieties of *Taxus cuspidata* were generally the most seriously affected, although many closely-sheared specimens of *capitata*, *media*, and *hicksi* varieties were also found heavily infested.

Usually the first indications of injury to the plants are yellowing and dropping of leaves. Growth is greatly diminished and, as occasional twigs die, the plant presents a thinned and sickly appearance. If the infestation is unchecked, plants may become worthless and finally die. This decline is aggravated by unfavorable growing conditions.

Comstock's mealybug hibernates here only in the egg stage, and during the winter and early spring the small, oval, orange-red eggs are found in grayish wax masses in the axils of the twigs and leaves, particularly toward the inside of the plant where they are well protected. The young crawlers emerge in the spring after about two weeks of warm weather, very shortly after new growth has started, and commence feeding at the base of the old needles and on one- and two-year twigs. As the mealybugs develop, they migrate over the entire plant, feeding on both new and old leaves and shoots. There are several, two to three, overlapping generations a year and, with the exception of early spring, all stages are found throughout the growing season.

Control

Chemical control is a problem of contacting and wetting the insect and its eggs within the waxy masses with a material which will not injure the foliage. The insect itself or the eggs are rather easily killed by most of the common contact insecticides, if the waxy covering is dissolved or penetrated so that they are actually wetted.

For preliminary tests, twigs containing egg masses and adults were brought into the laboratory and dipped for five seconds in the various insecticide mixtures, and any composition which did not cause a high kill under these conditions was eliminated.

Forty per cent nicotine sulfate at the rate of one pint per 50 gallons of water, plus soap at the rate of six pounds per 100 gallons, caused practically no kill. At one quart to 50 gallons, the kill was only 60 per cent.

[1] See footnote 1, page 33.

DDT at the concentrations of 0.5, 1.0, and 2.0 per cent applied to potted yew plants as a water suspension, and in oil-water emulsion, with an effective wetting agent, Nacconal N. R.[1] at the rate of 4.0 ounces per 100 gallons did not cause an appreciable kill of mealybugs. Three to five days after treatment many mealybugs were exceptionally active and were observed crawling away from the treated plants, but only a few were found dead. Two weeks later all stages were abundant on the plants treated with DDT, and there appeared to be no significant reduction in the mealybug population. DDT in vapor form was likewise ineffective. But hymenopterous parasites of the mealybug which had been abundant were eliminated by these treatments.

Lethane 440 diluted by volume, 1-300 water, killed 88 per cent of the adults and eggs. The survivors were protected by dirt and heavy wax. At the dilutions of 1-600 and 1-1200, wetting and penetration were insufficient.

Kerosene emulsion (Ultrasene, specific gravity .76) at 1.5 per cent gave a fair kill of exposed individuals but a poor kill within the masses. At 3 per cent concentration, 80 per cent were killed and, at 6 per cent, the kill was complete.

Lime sulfur. Wetting and penetration of lime sulfur mixtures under accumulations of clay and into waxy masses were improved also by the addition of the wetting agent, Nacconal N. R., at the rate of four ounces per 100 gallons. This was used for all tests with lime sulfur. At a dilution by volume of one part liquid lime sulfur to 39 parts water, a few eggs and crawlers escaped in the thickest masses, giving a kill of approximately 85 per cent. At 1-19, 1-13.3 and 1-9, the kill was complete in every test.

From these trials it was apparent that lime sulfur and kerosene emulsion were the most effective materials tested. However, kerosene emulsion and other similar petroleum oils can seldom be safely used on yews because of the danger of foliage injury.

When liquid lime sulfur at one to nine parts water was applied to heavily infested, large, potted yews in the greenhouse, the newly started growth was killed back and slight injury occurred to older foliage. In addition, the plants receiving this treatment failed to "come back" properly that season even though the mealybug infestation was completely eliminated. Plants sprayed with a 1-19 dilution received slight injury to the new growth but recovered quickly and the kill of mealybugs in all stages was complete. At 1-39 there was some survival of both eggs and bugs.

It should be recognized that lime sulfur, at any of the dilutions tested, leaves a grayish residue on the foliage which persists for about

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[1] Supplied by the Naugatuck Chemical Company through the courtesy of Dr. T. W. Kerr.

Nacconol N. R. is an alkyl aryl sulfonate (not a sulfated fatty alcohol).

two months, so infested plants which are to be sold in the spring should be treated the previous fall. These tests further suggest that foliage injury can be avoided by treating when the plants are dormant and at a time when the temperature will not fall below 32° F. for 24 hours.

Determination of the advisability of treatment will rest largely with the grower. A heavy infestation may cause serious loss by inhibiting growth, particularly with the dwarf varieties. If the entire plant receives approved fumigation before shipment, the mealybugs will undoubtedly be killed but, if the grower is particular about the appearance of the plants, fumigation at the time of shipment would not be completely satisfactory because the dead bugs and wax masses remain on the plant for a considerable time. It is believed that a late fall application of liquid lime sulfur at one part to 19 parts water will generally be the most satisfactory treatment.

Summary

Comstock's mealybug is widely distributed on *Taxus* spp. in Connecticut and has recently become a serious pest in certain nursery plantings. Hibernation occurs in the egg stage and the crawlers emerge after about two weeks of warm weather in the spring. There are two to three generations per year.

Several insecticides were tested and liquid lime sulfur at 1-19 with a wetting agent, applied while the plants were dormant, was a satisfactory and highly effective treatment.

USE OF DDT DUSTS TO CONTROL WEEVILS ON SEEDS

Neely Turner

The efficacy of lime as an insecticide to control weevils on peas was discovered by Metcalf (1917) after a series of treatments with dosages ranging from four parts of lime to one part of seed (by weight) to one of lime and 11 of seed. He suggested the use of at least one part of lime and two parts of seed. Mackie (1925) found that copper carbonate used at the rate of two ounces to a bushel of wheat seed effectively controlled rice and grain weevils, various species of grain beetles and the Angoumois grain moth.

Zacher (1929) confirmed the action of copper carbonate and investigated and reported that copper salts acted in inverse ratio to their solubility. Finely divided copper was not toxic. Oxides and carbonates of magnesium and zinc were found to be toxic. Zacher and Kunike (1930) found that alkalinity was not involved, because finely ground compounds of silicon were also effective. The materials acted to cause a loss of weight of the treated insects, probably because of loss of water. In damp air the dusts were not effective.

Chiu (1939a) determined the effect of particle size of crystalline silica on toxicity. The time required to kill a given percentage of bean weevils was less as the particle size was decreased. He also measured the differences between materials and found that crystalline silica was much more toxic than amorphous silica. He confirmed this work (Chiu, 1939) on rice and granary weevils, and also showed that increase in relative humidity decreased toxicity.

Jenkins (1940) and Fitzgerald (1944) in Australia studied several materials for protection of grain. Briscoe (1943) in England investigated the method and found suitable materials for protecting grain. Particle size was important; the maximum effectiveness seemed to be between one and two micra. Rough particles were more effective than smoothly rounded ones of the same particle size. The findings of Parkin (1944) were substantially the same as those of Briscoe. Parkin offered the hypothesis that the hard particles of dust interfered with the continuity of the water-retaining lipoid layer of the cuticle.

Cotton and Frankenfeld (1945) suggested the use of either magnesium oxide, one ounce to a bushel of seed, or 3 per cent DDT dust at one-half ounce to a bushel. Farrar (1945) reported complete control of grain pests following use of one ounce 5 per cent DDT dust to a bushel of grain. Packard (1945) reported that wheat was protected by .05 per cent by weight of 3 per cent DDT dust, or about one-half ounce per bushel.

Experimental. The effect of DDT dusts on adults of the bean weevil was studied in the laboratory in November, 1944. Preliminary tests showed that as little as .0625 per cent by weight of 4 per cent DDT dust (approximately .025 ounce DDT per bushel of seed) killed all the adult bean weevils on treated seed within three days. Use of a .5 per cent DDT dust showed that as little as .125 per cent by weight of seed killed all the weevils within four days. It was noticed that much of the dust used in treating the 100 gram samples stuck to the sides of the glass bottle. Tests were therefore made on the beans removed from the treating jars. The results of three replicate tests using 25 weevils in each test were as follows:

	Effect on bean weevils—3 days		
Amount ½ per cent DDT dust	No. dead	No. alive	Per cent dead
.5 g. – 100 g. seed	70	5	93.3
.25 g. – 100 g. seed	69	6	92.0
.125 g. – 100 g. seed	60	15	80.0
.0625 g. – 100 g. seed	43	32	57.3
None	5	70	6.7

A test of coverage was made by applying 1 per cent, 2 per cent and 4 per cent DDT dusts to bean seed at four dosages. Four tests were made by adding 25 bean weevils to each sample, and determining mortality after three days. The results were as follows, with all percentages based on 100 weevils in four replicates:

1 Per Cent Dust		2 Per Cent Dust		4 Per Cent Dust	
Dosage	Per cent dead	Dosage	Per cent dead	Dosage	Per cent dead
.25 g./100 g. seed	**78**	.125 g./100 g. seed	78	.0625 g./100 g. seed	82
.125 " "	**72**	.0625 " "	72	.0313 " "	77
.0625 " "	65	.0313 " "	62	.016 " "	61
.0313 " "	45	.016 " "	35	.008 " "	44

These results indicate that within the limits of this experiment it made little difference whether a given amount of DDT was applied as 1, 2, or 4 per cent dust. The amount of dust required for a high degree of control was relatively low. It was, however, about the same quantity as Jenkins (1940) reported was necessary to control stored grain pests when calcined diatomaceous earth was used.

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SEED TREATMENTS TO CONTROL SEED CORN MAGGOTS

NEELY TURNER

The high toxicity of DDT to the larvae of flies (Simmons and Wright, 1944) suggested its use to control the seed corn maggot. Lima beans were treated with 3 per cent DDT, *Spergon* (Chloranil), and both *Spergon* and DDT. The treated seed and an untreated check were planted 10 seeds in a plot, randomized in each of four blocks. Plantings were made at weekly intervals starting May 7, 1945. The weather was cold and wet, and none of the seeds germinated. Subsequent plantings made May 15 and 22 were heavily infested by seed corn maggots, and were examined June 15. A summary of the results is given in Table 43. The concentration of the treatment is by weight of seed.

TABLE 43. EFFECT OF SEED TREATMENT ON SEED CORN MAGGOT

Material	Conc.	Number of seed: Sprouted	Number of seed: Normal plants	Total infested[1]
		Planted May 15		
Spergon	1.0%	24	17	36
	.5	14	8	28
	.25	21	14	36
	.125	10	6	31
DDT (3% Dust)	1.0%	4	1	26
	.5	10	7	30
	.25	3	1	25
	.125	9	5	29
Both DDT and Spergon	1.0%	19	13	35
	.5	19	14	31
	.25	16	10	28
	.125	15	10	30
Check	...	5	3	28
		Planted May 22		
Spergon	1.0%	20	18	37
	.5	23	19	31
	.25	24	19	39
	.125	17	15	34
DDT	1.0%	3	3	31
	.5	5	4	33
	.25	8	7	36
	.125	6	5	26
Both DDT and Spergon	1.0%	16	14	38
	.5	19	15	36
	.25	19	16	37
	.125	7	5	28
Check	...	7	6	29

[1] Including seeds that did not germinate.

There was no marked reduction in the infestation of seed corn maggots following any of the treatments. The low figure for infestation of the untreated checks is probably not a true estimate of the infestation. A great many of the seeds rotted and could not be found when the examination was made.

The largest number of normal plants was produced by treatment with *Spergon*. When DDT was added, there was no evidence of control of the seed corn maggot. The DDT apparently affected *Spergon*, however, as evidenced by the lower number sprouted and by the smaller number of normal plants, particularly in the May 22 planting. It is possible that the concentration of DDT was too low for effective control of this pest. However, Simmons and Wright used as little as 0.1 per cent DDT in emulsions with good results.

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WIREWORMS ON POTATOES

D. E. Greenwood

Wireworm control investigations during 1945 continued along the lines of previous years. Practically all of the work was carried on either in the greenhouse during the winter months or the field laboratory during the growing season.

D-D Mixture[1]

Field applications in May, 1945, using 600 gallons of dilute emulsion (400 pounds crude D-D Mixture) per acre were unsuccessful even though wireworms were actively feeding on rye roots at the one-inch level. The early part of the 1945 season was unusually wet and the general belief is that D-D Mixture is more effective in dry soils than in wet soils. The material not only had no lethal effect under these conditions but even failed to deter the wireworms from their feeding activities.

DDT

Adults. It was reported in 1944 that 3 per cent DDT dust[2], applied to the soil surface, was effective against the adults of the eastern field wireworm and that field tests were to be run in 1945. Because of the unusually rainy weather during flight period, there was little beetle activity and the dusts were washed in as soon as they were applied. The results of a limited number of field trials substantiate the laboratory evidence reported last year. In general, 50 pounds

[1] Dichloropropane-dichloropropylene.
[2] Gesarol A.

of a 3 per cent dust per acre could be expected to be effective, but only under ideal conditions. If the flight period were drawn out over three or four weeks, or if more than occasional showers were expected, 100 or even 200 pounds of dust per acre would be necessary. One apparent disadvantage to such a control practice is that the flight period comes at a time when most fields are under cultivation in one form or another.

Larvae. Results from the 1944 field and laboratory work suggested that soil treatments with DDT left much to be desired for wireworm control and that, if DDT were to be used successfully against the larvae, other methods of application would have to be employed. Accordingly, laboratory tests were made early in the 1945 season in which the larvae were brought in contact with surfaces sprayed with a concentrated DDT preparation and on which a heavy deposit of DDT was visible. The inconsistency and uncertainty of the results of these tests led to the incorporation of DDT in baits. This method of using DDT proved satisfactory in the laboratory under certain conditions and will be tried in the field in 1946.

Contact Treatments

Generally speaking, all contact treatments produced some mortality but only of a very low order. The most pronounced effect of treatment was the inability of the larvae to feed to any degree as compared with larvae in the controls. Even this effect soon wore off, but feeding appears to be a very uncertain criterion upon which to base a comparison. The results obtained when larvae were placed in pots with sprayed potato seedpieces were of such a nature that this method of applying DDT cannot be abandoned yet. Most of the mortality was attributable to cannibalism, which in turn might have been the result of a pronounced hypersensitivity induced by coming in contact with the DDT deposit on the seedpiece. This hypersensitivity was not observed in other contact treatments.

DDT Baits

The most successful method of using DDT for wireworm control was that in which the DDT was added to a bait to which the larvae would readily come to feed (in the absence of other food). Only a few materials were tested since the method of control, and not the materials, was the principal point of interest. Ground wheat cereal proved readily acceptable as food to the wireworms and did not give off strong ammonia fumes upon decomposition as did cottonseed and soybean meal. Because of the small amounts of DDT desired (large doses were repellent), it was added as a 3 per cent dust to the dry cereal and the whole mixture moistened with water. The individual baits were about an inch and a half in diameter and were placed in containers of soil before introducing the larvae. Approximately 300 larvae were used in the tests.

The amount of actual DDT per pound of dry bait varied during the course of the work but in the majority of cases it did not exceed one-quarter to one-half gram. Lower dosages were not attempted because it was felt that the amounts were already small enough to be certain of proper distribution throughout the bait.

NOTES ON THE FEEDING OF WIREWORMS

R. L. Beard

In potato fields heavily infested with wireworms, a period of intense feeding activity of the wireworms is usually to be observed soon after the time of planting. The feeding activity then appears to subside until later in the summer when the potato tubers are of some size, at which time feeding activity is accelerated again. With a view to elucidating some of the feeding habits of wireworms, observations were made on the feeding and molting activities under laboratory conditions.

The Feeding Pattern of Wireworms Relative to Temperature and Molting

Some 120 wireworms were incubated in individual vials or jars, half of them being kept at a temperature of 75° F. and the rest at a temperature of 85°. Half of each group was fed potatoes, and the remainder was fed sprouting wheat, fresh food being given at the time of each observation. The wireworms were examined approximately twice weekly, feeding activity was noted and molting, as evidenced by cast skins, was recorded.

Fourteen wireworms failed to molt during the course of the experiment. There was nothing distinctive about the feeding pattern of these individuals, and there were no apparent differences associated with temperature.

From the observations on the feeding activities of the other wireworms, which did molt, no definite conclusions can be drawn. The feeding pattern seemed almost entirely a random one, affected neither by the temperature nor food differences used in this test. There was a definite tendency, though not invariable, for a period of fasting to precede a molt, and there was a suggestion of a tendency for a period of feeding to follow shortly after the time of molting. This was not consistent enough, however, to explain much of the mass feeding pattern observed in the field.

Growth, Molting and Mortality as Affected by Feeding Conditions

The effect of feeding conditions on growth and mortality was observed by incubating wireworms in soils containing different quantities of available food. In all cases Windsor soil was used, but one portion was ignited to remove the organic matter. In another portion the organic matter was increased by the addition of liberal quantities of leaf mold. Another portion was left unaltered. A fourth portion was left unaltered but wheat grains were added to provide food for the wireworms.

In one series of observations, utilizing 40 individuals, wireworms were incubated under the four feeding conditions described and individually weighed at intervals of about twice weekly to determine if changes in body weight would indicate the utilization of organic matter in the absence of growing plant food.

It was only among those wireworms which were provided with wheat grains that there was an increase in body weight. Among those living in ignited soil there was a progressive decrease in body weight. There was also some loss, though less noticeable, among those wireworms incubated in unaltered soil and in that fortified with organic matter. Between the last two groups there was no appreciable difference.

On the basis of this single experiment which was not replicated nor repeated, it appeared that wireworms require growing plants for food if they are to gain in weight, and it is doubtful if organic matter present in the soil is utilized to any appreciable extent in maintaining metabolism.

In this and in another series incubated under similar conditions, the molting trends were observed. During the course of the observations, some wireworms molted as many as three times, but the majority molted only once. In all groups there was at least some tendency for a high frequency of molting during the early period of observation after the wireworm had been removed from cold storage. There were also subsequent periods of high frequency in the various groups, but no pattern was apparent which could be associated definitely with feeding activity. Even those individuals maintained in the absence of organic matter molted as freely as those in the other groups.

Among the groups of wireworms incubated under different feeding conditions, mortality trends showed some aberrancies, but these did not seem to be associated with the presence or absence of food. For example, in one series, the group reared in ignited soil exhibited lower mortality than other groups. On the other hand, in the second series, one of the groups provided with sprouting wheat showed much higher mortality than other similar groups. Due to a mechanical failure of the rearing cabinet, causing the death of all wireworms, the observations were terminated before all the individuals either completed their development or succumbed. Consequently, the observed mortality trends were for a period of only about three months.

A STUDY OF THE RELATIONSHIP BETWEEN ORGAN AND ORGANIC ENVIRONMENT IN THE POST EMBRYONIC DEVELOPMENT OF THE YELLOW FEVER MOSQUITO

Aedes Aegypti

DIETRICH BODENSTEIN[1]

The characteristic sequence of events exhibited by a developing organ is the result of a closely coordinated interplay of action and reaction between the organ itself and its organic environment. For an understanding of the causal factors in development, it becomes necessary to know which part of the chain of developmental events is played by the organ and which by the organic environment.

In the present investigation, this problem was attacked experimentally by transplanting identical organs into different environments. These transplants were then compared as to their developmental behavior. The results thus obtained allow conclusions to be drawn as to the nature of the environmental forces acting upon the organ, while the observed responses of the organ bring to light some of its developmental potencies.

Material and Methods

The yellow fever mosquito, *Aedes aegypti*, was used for this study. This mosquito is easily reared in the laboratory. The females need a blood meal before the eggs develop and are laid. Since only a relatively small number of mosquitoes was needed for this investigation, they were fed with human blood. The larvae were reared from eggs which were held in cold storage on moist filter paper until needed. For hatching, the desired number of eggs was submerged in tap water which included some food. The larvae usually emerged within two to four hours. They were reared in tap water and fed on powdered dog food. Within about five days at 28° C., the larvae reached maturity and pupated. The pupae hatched two days later. The adults to be operated upon were kept in glass vials closed with cotton gauze stoppers. They were fed on sugar water; for this, a cotton ball saturated with sugar water was placed at the bottom of the vial.

The transplantations were made with the same injection apparatus used in transplantation experiments on *Drosophila* (Beadle and Ephrussi, 1936). Only adults were anesthetized with ether for the operation, the pupae and larvae being placed on moist cotton without anesthesia. The animal was held in place on this cotton operating table by a few fibers of cotton which were drawn over it. The tissues used for the transplantations were dissected in insect Ringer (one liter distilled water, NaCl 7.5 gr., KCl 0.35 gr., $CaCl_2$ 0.21 gr.) and injected into the abdominal cavity of the host where they floated loosely in the body fluid of the animal. Both pupae of all ages and adults are

[1] Formerly Connecticut State Board of Mosquito Control; now Medical Research Laboratories, Edgewood Arsenal, Edgewood, Md.

relatively easy to inject and withstand the operation quite well. The larval operations, however, are much more difficult, since the puncture of the body wall by the injection needle is always followed by the loss of a great amount of blood. This weakens the animal to such an extent that it is unable to hold itself to the surface of the water, and usually sinks to the bottom of the culture dish, where it suffocates before it regains its strength. If the transplanted tissue is small, a finer bore injection needle can be used and the rate of mortality is much lower.

For histological studies the animals were fixed in alcoholic Bouin (hot), embedded over methyl benzoate in paraffin and sectioned at 10 microns. The sections were stained with Delafield's hematoxylin and counterstained with Orange G. Total mounts were prepared in many instances; these were stained with orcein and mounted in diaphane.

Experimental Part

Transplantation of Malpighian Tubes

This group of experiments was designed to test the growth capacity of very young larval organs in different organic environments. The tissues used were Malpighian tubes. These organs were taken from completely developed larvae dissected out of stored eggs. Parts of the intestinal tract were usually left attached to the Malpighian tubes at dissection. These transplants were then put into the desired environment. These egg larvae were used as donors in order to obtain material uniform in age.

To provide a basis for comparing the degree of development reached by the transplanted tubes with that of normal development, a series of normal developmental stages was prepared, as shown in Figure 17. Figure 17-a shows a Malpighian tube of an egg larva and thus represents the transplant at the time of transplantation. Figure 17-b is a tube of a 1st, Figure 17-c of a 2nd, Figure 17-d one of a young 4th and Figure 17-e one of an old 4th instar larva. By adding the signs + or – before the letter signifying each stage, one can indicate that development is a little more or less advanced than shown in the figure. In doing this, the staging becomes quite accurate and allows the recording of even small size differences.

The experiments are composed of three separate series, as follows: (1) Malpighian tubes transplanted into adult mosquitoes, (2) Malpighian tubes transplanted into young pupae, (3) Malpighian tubes left in their larval environment and the young larvae then grown for the desired length of time. In all cases save four (See Table 44), the transplants were allowed to develop for two days in their respective environments. They were then dissected out, stained, mounted and compared with the normal developmental series and with each other.

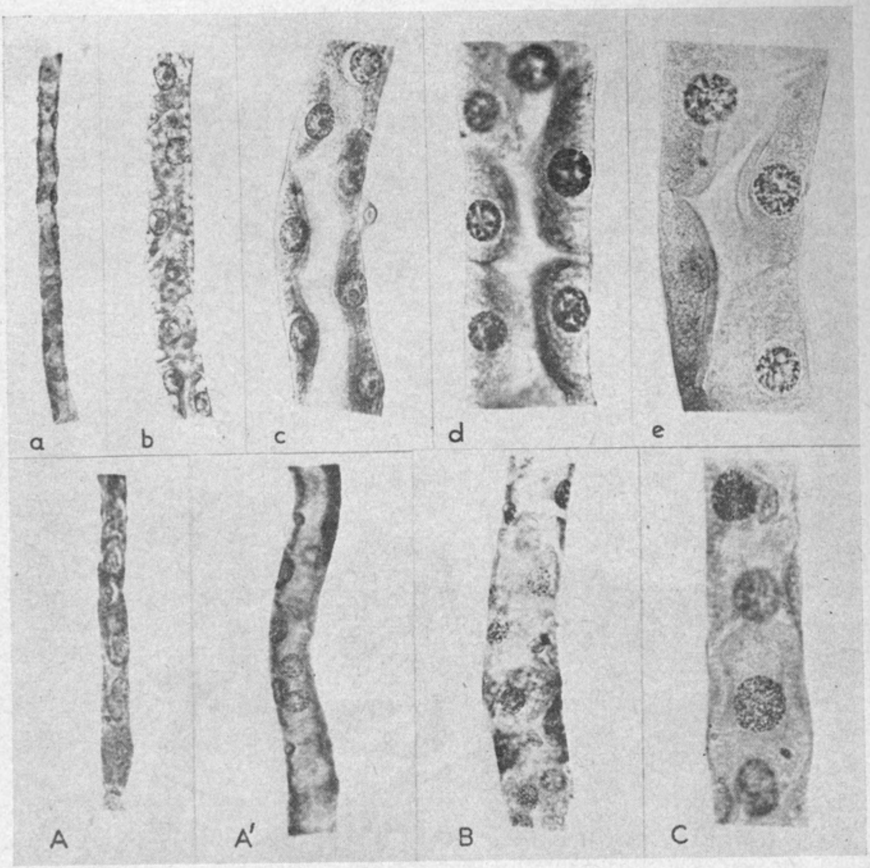


Figure 17 a - e. Normal development of larval Malpighian tubes.

- a. Malpighian tube of egg larva.
- b. Malpighian tube of 1st instar larva.
- c. Malpighian tube of 2nd instar larva.
- d. Malpighian tube of young 4th instar larva.
- e. Malpighian tube of old 4th instar larva.
- A. Malpighian tube of egg larva cultured for 2 days in the abdomen of an adult fly.
- A'. Malpighian tube of egg larva cultured for 5 days in the abdomen of an adult fly.
- B. Malpighian tube of egg larva cultured for 2 days in the abdomen of a pupa.
- C. Malpighian tube of a two-day-old larva.

Table 47 summarizes the results of these experiments. They show that the transplanted tissue grows in all three environments. The best growth is exhibited by Malpighian tubes in their own larval environment. The pupal environment still promotes considerable growth, while the least growth takes place in the adult host. Figure 17-A, B, C illustrates the situation clearly, showing the different de-

TABLE 44. TRANSPLANTATION OF MALPIGHIAN TUBES FROM EGG LARVAE

Environment	Days transplant remains in host	Stage of development reached
Larva	2	d
"	2	d
"	2	d
"	2	d
"	2	d
"	2	e
"	2	e
"	2	e
"	2	e
"	2	e
"	2	e
Pupa	2	c–
"	2	c–
"	2	c–
"	2	d
"	2	c–
Adult	5	c
"	5	c
"	5	c–
"	4	c–
"	2	b–
"	2	b
"	2	b
"	2	b

grees of development reached by each tube which was cultured in different environments for the same length of time. Although but little growth takes place in the adult environment, growth does not cease after two days, but continues at a slow rate. This is shown by the fact that Malpighian tubes left for five days instead of two days in the adult host are larger than the two-day-old transplants, as can be seen if one compares Figure 17-A with Figure 17-A′.

Incidentally, the same developmental behavior as exhibited by the Malpighian tubes in the three environments tested is followed by the pieces of intestinal tract which were transplanted together with the tubes. These tissues are strictly larval organs and disintegrate during metamorphosis, in contrast to the Malpighian tubes, which maintain their identity during pupal life and are but slightly changed. It is interesting in this connection to note that purely larval organs, such as the larval intestines, are able not only to maintain themselves but also to grow in an imaginal environment. Moreover, the type of growth exhibited by the larval intestine in the adult environment is characteristically similar to that performed by the organ in its own larval environment; that is, there is an increase in cell size.

Transplantation of Imaginal Discs

The donors which furnished the transplants in this second group of experiments were larvae of the last instar instead of young egg

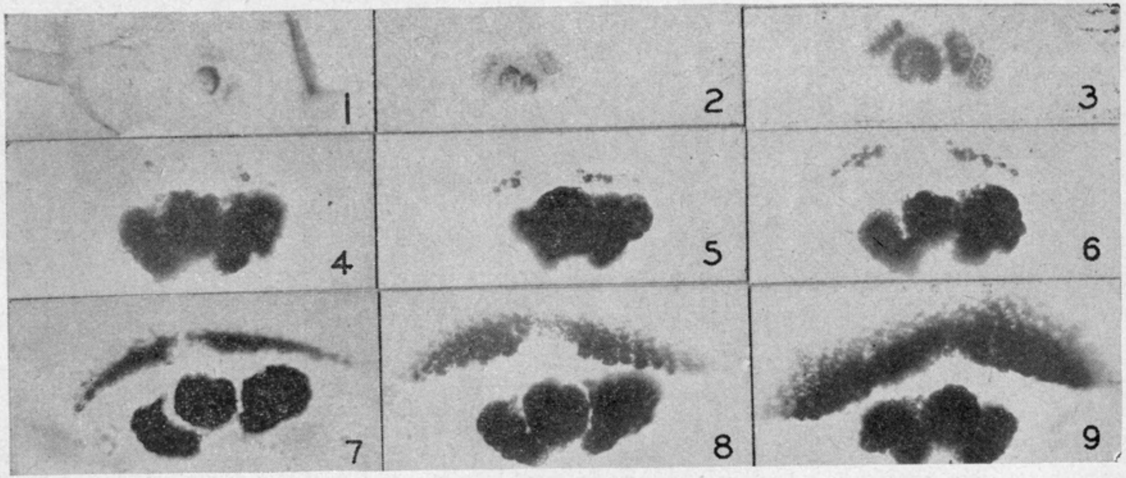


Figure 18. Stages in the development of the larval and imaginal eye during larval life. 1. Larval eye of a 1st instar larva. 2. Larval eye of a 2nd instar larva. 3. Larval eye of a 3rd instar larva. 4 - 9. Larval eyes of successively older last instar larvae. Note the appearance of imaginal eye pigment above the larval eye. Note also the increase of the pigmented area as the larvae become older.

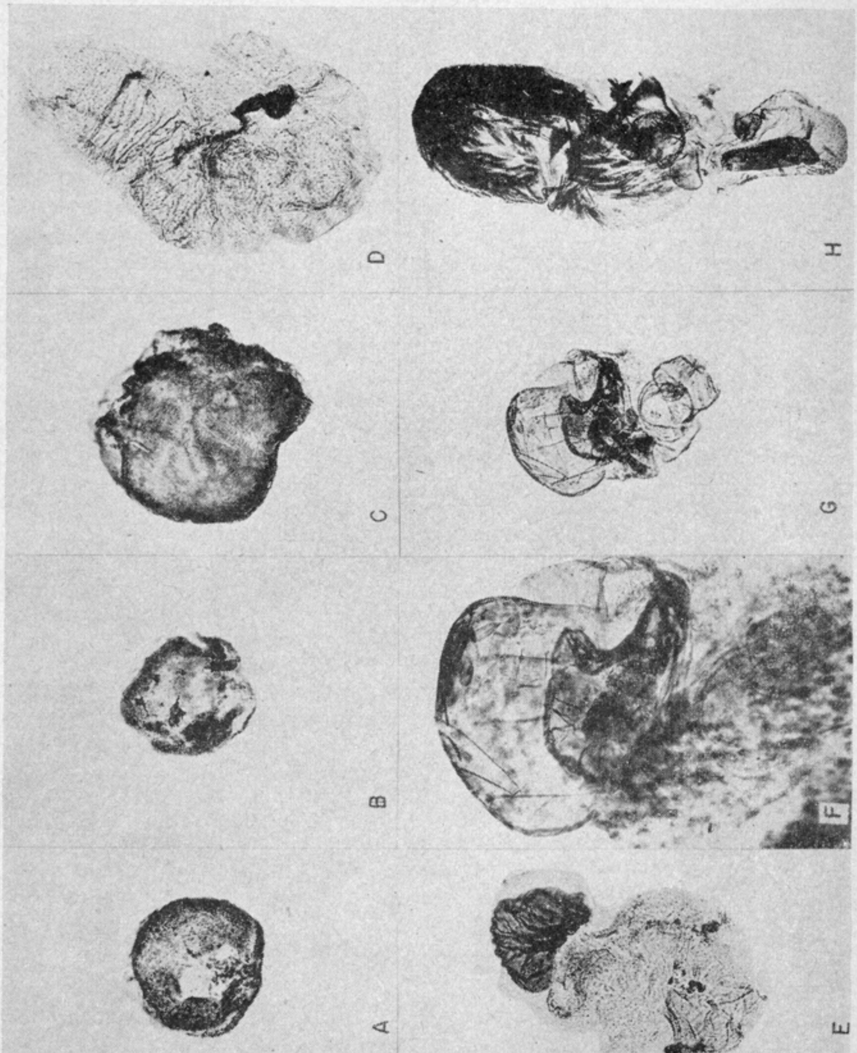
larvae. The organs transplanted were the so-called thoracic discs, which represent the primitive anlagen of the future wings and legs of adult organisms. The anlagen have already undergone their main larval growth prior to the transplantation; this is in contrast to the Malpighian tubes of the previous experiments, which at the time of transplantation had their larval growth period still ahead of them. The imaginal discs, moreover, grow mainly by cell multiplication, and not by cell size as the Malpighian tubes do. During metamorphosis the imaginal anlagen are changed much more drastically than the Malpighian tubes. They are transformed from a rather primitive larval state into the highly specialized structure of an adult leg or wing, as the case may be. Each thoracic disc, whether it may be the future leg, wing or haltere, gives rise not only to the structure implied by its name but also furnishes part of the thoracic hypoderm of the adult insect. Exactly how much each disc contributes toward this goal is not known. Since in the mosquito an active pupal stage is inserted between the larval and adult stage, the thoracic discs are apparently also involved in the formation of the thoracic hypoderm of the pupae, as the following experiments seem to indicate.

To provide material uniform in age for the transplantation experiments, the last instar larvae were staged by using the pigmentation of the imaginal eye as a criterion of age. The imaginal eyes in this species begin differentiation quite early in larval life. By the time the larvae pupate, the imaginal eyes have reached a rather advanced state of differentiation. During the last instar, the imaginal eye structure becomes clearly visible by the formation of pigment in the ommatidia.

Pigment appears first in that part of the imaginal eye nearest to the larval eye. As development proceeds, more and more ommatidia become pigmented and, consequently, the pigmented area becomes larger and larger. At the time of pupation, the imaginal eye pigment forms a wide crescent-shaped area above the larval eye. The amount of pigment present in the imaginal eye at any given time is thus a useful tool for determining the age of last instar larvae. Six different stages of pigmentation (Stages 4-9) have been distinguished following three earlier stages of development. (Figure 18).

Transplantation of Imaginal Discs into Adult Hosts

Thoracic discs of eye stage 7 to 8 were transplanted into the abdomen of adult hosts. The discs were allowed to remain for four to nine days in their new environment. Table 45 summarizes the results. The discs changed but little, whether they remained for four or nine days in the adult host. But in several cases a little growth was observed. No sign of imaginal differentiation, as indicated by sclerotization, could be detected. The general appearance of the discs, as far as size and state of development are concerned, scarcely changed during their stay in the adult host. This is illustrated in Figures 19-A


A
B
C
D
E
F
G
H

and 19-B, which show a disc of stage 7 at the time of the operation and a disc of the same age which had been in the adult host for four days.

Transplantation of Imaginal Discs into Pupal Hosts

Imaginal discs of eye stage 7 to 8 were transplanted into the abdomen of very young pupae, where they remained for two days until

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Figure 19-A. Thoracic disc (stage 7) at time of transplantation (stained preparation).

B. Thoracic disc transplanted at stage 7 into the abdomen of an adult host. Four days after the operation (stained preparation). Note: No growth has taken place.

C. Thoracic disc transplanted at stage 7 into the abdomen of a pupal host. Two days after the operation (stained preparation). Note: Increase in size of disc.

D. Thoracic disc (wing) transplanted at stage 7 into the abdomen of a pupal host. Two days after the operation (unstained preparation). Note: Disc has become much larger and is partly sclerotized. Black lines in photo indicate sclerotized areas.

E. Thoracic disc transplanted at stage 7 into the abdomen of larval host of stage 9. Three days after the operation (unstained preparation). Note: Disc is partly sclerotized and has become much larger. Large black portion in the anterior region of the disc shows pupal cuticle, while the darkish structure and lines in the posterior disc region show imaginal cuticle.

F. Anterior portion of transplant shown in Figure 19-G more magnified. Note: Bristles and scales formed by transplant.

G. Thoracic disc transplanted at stage 7 into the abdomen of a larval host of stage 8–. Four and one-half days after the operation (unstained preparation). Note: Transplant is completely differentiated.

H. Thoracic disc (wing) transplanted at stage 7– into the abdomen of a larval host of stage 7. Five days after the operation (unstained preparation). Transplant is completely differentiated. Note the development of typical wing scales.

the hosts emerged. All transplants continued their development in their new environment. As far as size is concerned, the transplanted discs had reached a state of development which corresponds to that reached by a normal disc in its own environment shortly before pupation. At this time in normal development the discs are ready to invaginate in order to form pupal extremities. Thus, the transplants had undergone that part of growth in the pupal environment which they undergo normally during the last stages of larval life.

TABLE 45. TRANSPLANTATION OF THORACIC DISCS INTO ADULT HOSTS

Stage of disc at transplantation	Days transplant remains in host	Condition of disc
7	4	Scarcely changed
7	9	" "
7+	4	" "
7+	4	" "
8–	4	" "
8–	4	" "
8–	4	" "
8–	4	" "
7–	6	" "
7–	6	" "
7–	6	" "
7	6	" "

On turning to consider the state of differentiation reached by the transplants, one finds that this varies greatly. Some of the discs have not differentiated beyond a late last instar stage (eye stage 9) (Figure 19-C), while others show a much more advanced state of differentiation as indicated by the presence of yellowish cuticle (Figure 19-D). This cuticle, an amorphous mass composed of a mixture of lighter and more heavily sclerotized regions, shows no cuticular structures such as bristles, hairs, or scales, and apparently represents the cuticular cover of the pupal organs. The cuticle of the transplanted pieces is yellowish-brown in color in contrast to the cuticle of a normal pupa, which has a more grayish appearance. This light coloration is apparently the result of the beginning but abortive effort of the transplant to sclerotize. The state of differentiation of the transplants would thus be comparable to that of young pupal structures.

Next, attention must be given to the fact that some of the transplants are less differentiated than others, for some had sclerotized, others had not. The main reason for this becomes clear if one looks into Table 46, where the experiments are summarized. One will note that the age of the discs used for transplantation varies. When discs at stage 7– to 7 were transplanted, no sclerotization was observed, while discs transplanted at stage 8– to 8 usually became sclerotized.

The variability in the degree of sclerotization observed is apparently a different matter and reflects differences in the age of the hosts. Although young pupae, from which the flies emerged two days after the operations, were always used as hosts, their age was not controlled exactly. Age differences of six hours might have existed in the host material. These differences could well account for the variation in the sclerotization of the transplants.

TABLE 46. TRANSPLANTATION OF THORACIC DISCS INTO PUPAL HOSTS

Stage of disc at transplantation	Days transplant in host	Condition of disc
7–	2	Grown, no color
7–	2	Grown, no color
7–	2	Grown, no color
7	2	Grown, no color
7	2	Grown, no color
7	2	Grown, no color
7	2	Grown, no color
7+	1	Grown, no color
8–	2	Grown, some yellowish color
8–	2	Grown, some yellowish color
8–	2	Grown, some yellowish color
8	2	Grown, very light yellow color
8	2	Grown, very light yellow color
8	2	Grown, with dark yellow color

Transplantation of Imaginal Discs into Larval Hosts

Thoracic discs of stage 7– to 7 were transplanted into the abdomen of last instar larvae of different ages. The transplants remained in their respective hosts until they emerged as imagos. Depending on the age of the hosts at the time of transplantation, the transplants remained from three to six days in their hosts. Since all the transplants were dissected shortly after the emergence of the host, and since the pupal period of this mosquito is two days, the transplanted discs remained for different lengths of time in the larval host environment. These time differences are reflected very clearly in the results of the experiments. In general it was found that all discs had developed pupal cuticle. The discs developing in younger hosts had finished their imaginal differentiation completely, while discs developing in older hosts reached much less advanced stages of imaginal differentiation. The experiments are summarized in Table 47 where the individual cases are arranged in two groups, according to their stage of imaginal differentiation. This table shows that when discs of about stage 7 are transplanted into slightly older hosts (about one stage older than the donors) complete imaginal differentiation is obtained. Well formed and fully colored cuticular elements, such as bristles, hairs and scales, are developed by the transplants, which differ in no respect from the identical cuticular structures of the host (Figures 19-E, 19-F, 19-G). The transplanted tissues apparently developed synchronously with the host, since they reached their final state of imaginal differentiation at the same time as the host. In other words, the discs developed normally in their new environment if they remained for two or more days in the larval host before pupation.

The discs behaved quite differently when they were transplanted into still older hosts, that is, when the time interval between transplantation and pupation of the host was further shortened experimentally. Experiments of this kind are represented in the second group of cases in Table 47. Here, the discs were transplanted into hosts of stage 9 and remained for two or less than two days in their new larval hosts before pupation took place. Imaginal differentiation of these transplants was not complete in this age combination. In some cases where differentiation was more advanced, cuticular structures such as bristles were formed, but the sclerotization was never complete. In other cases, only part of the transplant was slightly sclerotized, while large regions were still transparent and rather immaturely developed. In such discs, no bristles nor hairs were formed (Figure 19-H). The variation in the degree of differentiation within the different cases is undoubtedly due to differences in the age of the host at the time of transplantation.

TABLE 47. TRANSPLANTATION OF THORACIC DISCS INTO LARVAL HOSTS

Stage of disc at transplantation	Stage of host at transplantation	Days transplant remains in host	Condition of disc
7–	7+	6	Completely differentiated
7–	7+	6	Completely differentiated
7–	7	5	Completely differentiated
7+	8	4½	Completely differentiated
7	8	4½	Completely differentiated
7	8	4½	Completely differentiated
7	8	4½	Completely differentiated
7	8	4½	Completely differentiated
7	8+	4	Completely differentiated
7	8+	4	Completely differentiated
7	8+	4	Completely differentiated
7+	9–	4	Completely differentiated
7+	9–	4	Completely differentiated
7	9	4	Not quite completely differentiated
7–	9	4	Partly sclerotized, bristles formed
7–	9	4	Partly sclerotized, bristles formed
7	9	3	Not quite completely differentiated
7	9	3	Not quite completely differentiated
7	9	3	Partly sclerotized, large white regions, no bristles
7	9	3	Partly sclerotized, large white regions, no bristles
7	9	3	Partly sclerotized, large white regions, no bristles

Worthy of comment in this connection is another experiment in which the imaginal eye disc of donor larvae of stage 7 (two cases) and stage 9 (three cases) were transplanted into the abdominal cavity of hosts of the same age. In the cases reported above, where thoracic discs were transplanted into only slightly older hosts, the transplants always developed synchronously with the host and gave rise to a fully developed imaginal eye in the abdominal cavity. The only difference between a normal and a transplanted eye is that the lenses of the latter are directed toward the inside of the eye instead of projecting from the outer surface of the cup as in normal development. This peculiar situation has a very simple explanation. The elongated and flat cup-shaped imaginal eye of the larva contracts somewhat when dissected and rounds up after transplantation in such a way that the outer surface is folded inwards. It thus forms a hollow ball in which the retinal part of the ommatidia makes up the outer wall, while the part which forms the lenses is the inner surface. One can note further in these cases that the ommatidia of the transplants are much shorter than those in a normal eye. This is undoubtedly due to the abnormal spatial conditions the developing eye encounters in its new environment. Thus, purely mechanical factors restrict the increase in length of the ommatidia of the transplant (Bodenstein, 1939).

Discussion

The experiments have shown that growth of larval tissues can be greatly modified by altering the environment in which these tissues develop. Thus, identical Malpighian tubes grow best in a larval environment, and less well in the pupal and adult environments, respectively. True, the amount of growth in an adult host is quite small as compared with that in a larval host, yet growth may be considerable, even in an adult host, if the time the organ is allowed to remain in the adult host is increased. In other words, growth proceeds at a much slower rate in an adult environment. No matter how much growth is slowed down, there remains the essential fact that young larval Malpighian tubes can grow in an adult environment.

Quite different is the course of events taken by larval discs of the last larval instar. These organs do not grow at all when transplanted into adult hosts. Now these organs differ in two main aspects from the Malpighian tubes, and these differences seem to account for their different behavior. First, the imaginal discs grow mainly by cell multiplication, in contrast to the Malpighian tubes which grow by increase in cell size. Secondly, the transplanted discs came from last instar donor larvae; thus, they were physiologically much older organs than the Malpighian tubes. The main reason why the discs fail to grow in the adult environment must apparently be attributed to the loss of competence of these organs to respond to growth-promoting factors present in the adult animal. That these factors exist is shown by the growth of Malpighian tubes in the same environment.

There are, however, other possibilities to be reckoned with. The factors causing growth in Malpighian tubes might be different from those needed by the imaginal discs for their growth. But even if these factors are the same, there remains the possibility that their effectiveness in the adult environment is too low to promote growth in the imaginal discs, yet high enough to cause the Malpighian tubes to grow. A combination of these possibilities will apparently prove to be the real state of affairs encountered. As far as the Malpighian tubes are concerned, one finds that the growth factors are much more effective in a larval than in an adult environment, for identical Malpighian tubes, that is, organs which obviously have the same growth competence, grow better in a larval than in an adult environment. Moreover, these growth factors must gradually fall off as the animal approaches its imaginal state, since Malpighian tubes grow best in the larval, less well in the pupal and but little in adult hosts.

It has been seen that the growth competence, that is, the ability of an organ to respond with growth when called upon, varies within different organs. Apparently, the situation in regard to differentiation is similar. Identical discs will differentiate when transplanted into larvae, differentiation is less complete when they are transplanted into pupae, and no differentiation at all occurs in those discs grown in adult hosts. The same factors causing differentiation must be present in larvae; they must be less active in pupae and are apparently absent in the adult. This, however, is at best a rough generalization of the actual situation prevailing, as a close analysis of the different experimental series will show. Considering first the transplantation of discs into pupae, the following interesting facts become evident. If discs of stage 8– to 8 are grown in the pupal hosts, some sclerotization occurs, but no imaginal structures, such as hairs or bristles, develop. On the other hand, discs of stage 7– to 7, grown in the same environment, do not differentiate any cuticular structures. Since stage 8 discs are able to differentiate, it follows that the pupal host contains the factors necessary for differentiation. The reason that stage 7 discs do not differentiate must therefore lie in the discs themselves, for they are apparently unable to respond to these differentiation factors. Yet the situation is somewhat more complicated, as is brought out by the following consideration. True, stage 7 discs cannot respond with differentiation as stage 8 discs can, but these young discs continue their development in the pupal host, as indicated by their growth. In the pupal host they should reach stage 8, that is the reactive stage, and this they apparently do. Why then do they not differentiate after having reached this stage? The answer to this is given in the experimental series where discs of stages 7 and 8 were transplanted into adult hosts. In these cases even discs of stage 8 did not differentiate, which shows that the differentiation factors are missing in this environment. Therefore, we must assume that the young discs in the pupal environment reach their reactive stage at a time when the differentiation factors in the pupae have already disappeared or are so weakened as to be unable to cause differentiation.

The gradual disappearance of the differentiation factors during the course of pupal development becomes evident also in the experiments where stage 7 discs were transplanted into larvae of different ages (Table 47). One finds that discs of about stage 7 transplanted into larvae of stages 7 to 9– differentiate completely, while the same discs transplanted into stage 9 differentiate only partially. Since in this group of experiments all of the transplants remained for the same length of time in the pupal host but for various lengths of time in the larval host, it follows that their different developmental behavior must be attributed to the different lengths of time that they remained in the larval host. In other words, the transplants growing in younger hosts reached their responsive stage at a time when the differentiation factors were still present in the pupae and hence differentiated completely, while the transplants in older hosts reached this stage too late and could not get the full benefit of the differentiation factors, which resulted in partial differentiation only. Now there is one more point to be mentioned in this connection. In the case of complete imaginal differentiation, host and transplanted tissue apparently differentiate in synchrony with each other, although at the time of transplantation the transplanted discs and the hosts were of unequal age. Thus, some sort of regulation must have occurred. This can be explained as follows: under the influence of the differentiation factors of the host, the young discs must have started their imaginal differentiation earlier than they would have if left in their own environment. Either the young discs have grown faster and reached their responsive stage earlier than they would have in their own environment, or the differentiation factors were able to induce differentiation in the transplanted discs earlier, and the discs then have responded earlier than normally. According to the observation on other flies (Bodenstein, 1943), it is likely that both had occurred.

The experiments discussed above have brought to light the existence of growth and differentiation promoting factors in the organic environment of the transplant; and it has been recognized that in order to grow and differentiate, the transplant itself has to be competent to respond to these factors. Yet so far nothing has been said about the nature of these environmental factors. This question will now be discussed. In all experiments the transplants were placed into the abdominal cavity of the host, where they floated freely in the body fluid. The most intimate connection the transplants had with their hosts was thus the blood medium. The environmental factors we speak of are apparently located there. Obviously, the different environments tested have each their peculiar nutritive condition; therefore, one might think that nutritive factors are responsible for the developmental behavior of the transplant. In this case, the different competence of the transplanted organs would be the expression of their varied ability to utilize the different foodstuffs. However, nutritive factors are certainly not the main reason for the observed behavior of the transplanted organs, for experiments on *Drosophila* have shown that hormones circulating in the blood of the host animal control the developing organ to a large extent (Bodenstein, 1943). That the effects observed in the experiments reported here are also due to the action of such hormones becomes very probable if one recognizes the similarity in the results obtained in these and the previous experiments on *Drosophila.*

Summary

Malpighian tubes from egg larvae of Aedes were transplanted into the abdominal cavity of larval, pupal and adult animals. These organs grow best in larval, less well in the pupal and only a little in adult environment.

Imaginal discs were likewise transplanted into a larval, pupal and adult environment. In an adult host these discs are unable to differentiate. In a pupal host, the discs grow and begin to sclerotize. Sclerotization is, however, not complete. Discs transplanted into a larval environment and dissected at the emergence of the fly show complete imaginal differentiation.

Factors necessary for the differentiation of the imaginal discs are present in the late larval and young pupal hosts. These disappear, however, as the pupae become older. These factors, apparently hormonal in nature, are responsible also for the synchrony of development observed between transplant and host tissue. Younger tissues in older hosts will differentiate earlier than they would if left in their own environment. Discs of different age respond differently to the factors necessary for their differentiation.

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MISCELLANEOUS INSECT NOTES

Elm Lacebug (*Corythuca ulmi* O. and D.) This insect was very abundant on elms in Litchfield County. It is a sucking insect and is found on the under side of the leaves. By the middle of August most of the leaves had turned brown. We received several calls from people who were afraid the elms were infected with the Dutch elm disease.

M. P. Zappe

Termites (*Reticulitermes flavipes* Koll.) During 1945 we investigated 34 complaints of termites causing damage to homes and other buildings. In many cases the damage was slight and the owner was advised how to check it without expenditure of large sums of money. Occasionally the case called for some reconstruction work that was too big a job for the householder. As there was a shortage of carpenters and it was practically impossible to obtain copper flashing, a few people were advised to do nothing for a while until material and help could be obtained. Contrary to popular belief termites do not work very rapidly and a short delay in control measures would make very little difference in the amount of damage or in the final cost of eradication.

In most of the cases the owners reported the insects present before any serious damage was done. Only in one case was damage serious enough to warrant immediate reconstruction and this was in a farm house where termites had been present for quite a few years.

M. P. Zappe

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R. B. Friend

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