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CONNECTICUT STATE ENTOMOLOGIST

FORTY-SECOND REPORT

1942

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State Entomologist

Connecticut
Agricultural Experiment Station
New Haven

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

I have the honor to transmit, herewith, the forty-second report of the State Entomologist for the year ending October 31, 1942.

Respectfully submitted.

ROGER B. FRIEND,
State and Station Entomologist

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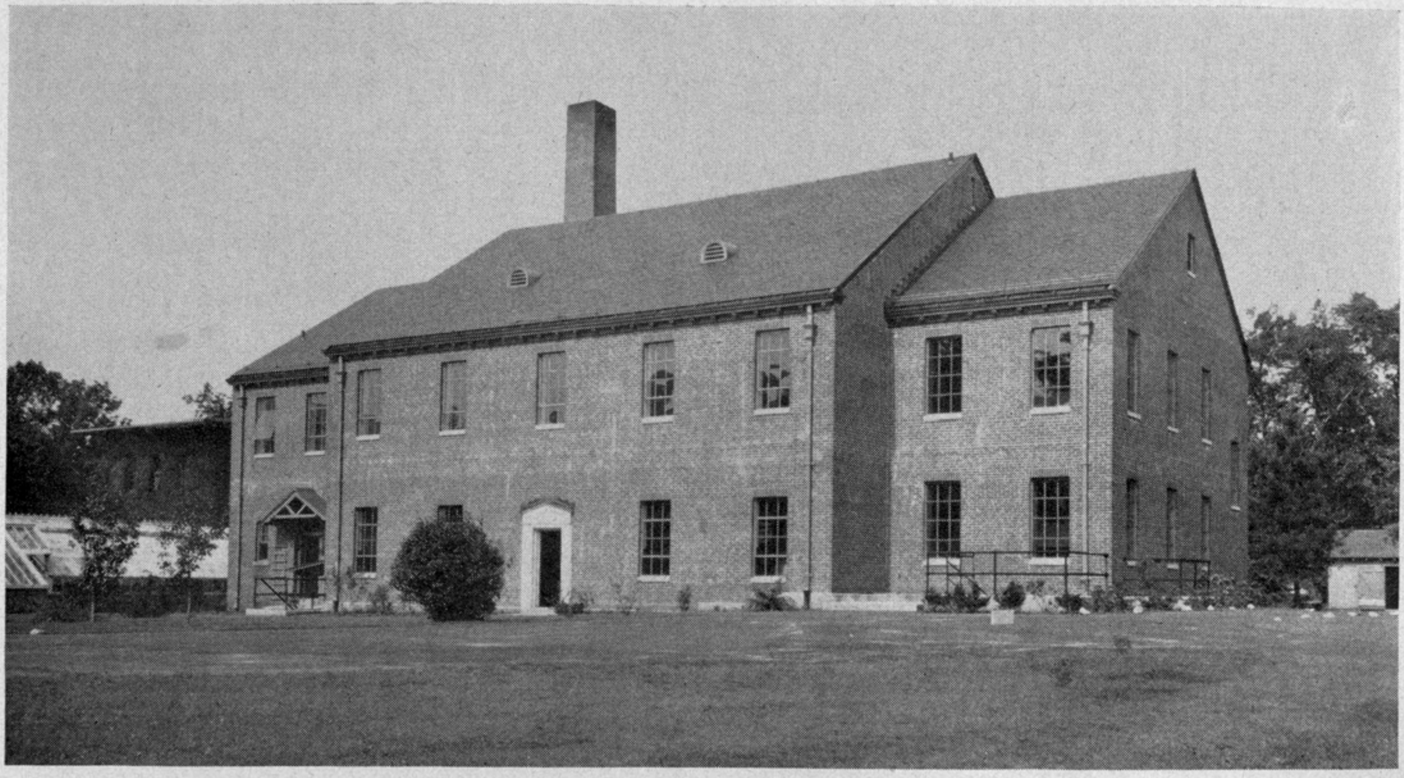

Britton Laboratory, completed the past year, includes a long-needed auditorium and parasite laboratories.

Connecticut State Entomologist

Forty-Second Report

1942

R. B. Friend

During the present war emergency, and perhaps for some time thereafter, Connecticut farmers will be expected to produce maximum crops of fruits and vegetables. In the production of these crops, adequate insect pest control is an important factor, for without it the harvest may be a failure. There is no virtue in raising crops to support insects or any other pests. The insect control problem, pressing enough in normal times, is made more acute by the current shortages of labor, supplies and equipment. Production must be efficient, and a comprehension of the factors involved will aid in attaining this efficiency.

Insect pest control is fundamentally the suppression of insect populations to an innocuous level. This is a poorly defined limit, but we can assume that if the insect is detrimental to human welfare, then the effort to suppress it should be extended until its injury has been reduced to an insignificant level. It is, of course, necessary to take the long view and realize that the ultimate effect of a control effort may not be immediately evident.

In suppressing the insect population, any estimate of results based on the percentage decrease may be very misleading unless there is some conception of the absolute population and its rate of increase. It is not the high proportion killed, nor the low proportion surviving, but rather the actual number surviving that is important. This has a significant bearing on the degree of control which must be attained if the crop is to be efficiently produced. If the insects are abundant, then a high degree of control is essential, as even a low surviving per cent means a large actual number. This is one of the reasons it is difficult to avoid plant injury during a heavy outbreak of, for instance, the Japanese beetle. If an insect has more than one generation a year and thus increases rapidly, then relatively few survivors may build up to an injurious population during a season. This is true of such insects as red mites and aphids in orchards.

Any methods of controlling the insect pests of fruits and vegetables must obviously be developed to cover a variety of conditions. The size and extent of the infestation, the value of the crop, the equipment and labor supply of the grower, and the skill of those carrying out the operations all vary. In control operations, quality, as indicated by appearance and flavor, should be considered, as well as per acre yield, even though the latter is the *sine qua non* of crop production. A control method that is to be used by a majority of growers to produce a large yield of high quality must be as nearly foolproof as possible. This implies the attainment of a high degree of control by the average grower.

As the degree of control obtained increases and approaches its theoretical limit, that of 100 per cent of either insect mortality or crop perfection, the effort expended in control must increase at an ever accelerated rate. These measures include the concentration or amount of insecticides, the number of doses, the care in applying, or anything else pertaining to the application. Thus, when working at high levels of control, increases in efficiency may be difficult to obtain. The converse is true, that any reduction in expenditure for control at these high levels may result in a relatively slight loss of effectiveness.

In the control of any particular pest on any one crop, one or several methods may be employed. Very frequently control methods supplement each other. It is not feasible to go into detail here, but certain general principles should be kept in mind. The use of insecticides has been developed further than any other general method. The smaller the number of pests present, the more effective is the insecticide. Few insecticides can be rated as perfect controls, however, even under the best of circumstances. For some pests no suitable insecticide control method is available. Certain other control operations may be essential to the successful use of an insecticide, and may even render the use of one unnecessary. Particularly during the present period of scarcities, the less insecticidal material applied the better, provided the crop yield does not suffer.

It is often possible to noticeably reduce the insect population, or its effect on plants, by what may be called cultural operations. That proper fertilization and cultivation are necessary to good crop production needs no further argument. Insect pests simply make a poorly grown crop poorer. Speeding up the growth of plants through proper soil fertilization may reduce the length of time they are exposed to insect attack. An example is that of the bean crop as affected by the Mexican bean beetle. Cultivation destroys some pests. The cultivation of peach orchards in the spring is said to reduce the abundance of oriental fruit moths which are then in the larval stage, many of them on the ground under the trees. Whether or not extensive cultivation of peach orchards is otherwise beneficial is another matter.

The rotation of crops is often of distinct benefit. Cruciferous crops are likely to suffer more severely from root maggots, and carrots from rust fly, if grown successively on the same ground. The date of planting is very important in avoiding injury by some pests. The earliest radishes can be harvested before root maggot injury occurs. Sweet corn harvested in August is usually so lightly infested by the European corn borer that use of insecticides is unnecessary. Snap beans planted during the first two weeks of June escape serious attack by the Mexican bean beetle.

The destruction of crop debris should be carried out promptly when it harbors pests. Corn stalks and long stubble constitute the principal hibernating quarters of corn borers and should be plowed under or otherwise disposed of before the last of April. Bean plants should be plowed under as soon as the crop is picked, as they otherwise form centers of infestation of the Mexican bean beetle. Likewise, it is important to destroy the common lamb's quarters, host of the spinach leaf miner, and other weeds that harbor pests.

The natural enemies of insect pests may sometimes be used with good effect. These enemies are always operative to a greater or less extent under natural conditions, but frequently we can increase their abundance and distribution. The milky disease of Japanese beetle grubs is a case in point. Although this disease will not eliminate the beetle from the State, if the disease becomes prevalent the grub population may fall to a non-injurious level and the adult beetle population to such a level that insecticides are more effective than at present. Hence the causal organism, a bacterium, is being distributed by Station entomologists as rapidly as it can be increased in the laboratory. The use of insecticides is not practicable on the oriental fruit moth, a serious pest of peaches in Connecticut. However, the principal larval parasite, *Macrocentrus ancylivorus,* when released in peach orchards, is proving quite effective in reducing the numbers of fruit moth larvae.

Although the individual grower is usually unable to increase the abundance of parasites and predators beyond what would naturally occur, he should realize their significance. If, for example, a field of young turnips is infested with aphids, and ladybeetles are unusually abundant on the leaves at the same time, these predacious insects may soon reduce the aphid population to a harmless level. Another aspect of the relation of predators to a pest population may be seen in the control of the European red mite on apple trees. Applications of sulfur apparently affect the enemies of the red mite so deleteriously that an outbreak of the pest may ensue. Yet on scab-susceptible varieties of apples it is considered necessary to use sulfur, which complicates the problem.

The use of insecticides during war time is handicapped by a scarcity of certain materials, making it necessary to stretch the supply and to use alternatives. It is unnecessary to enter into all the details of this problem here, as this subject has been discussed adequately by Turner and Horsfall,[1] but some of the methods of conserving the supply should be mentioned. The injury should be accurately diagnosed; that is, the causal organism should be determined and its possible injuriousness known. The correct insecticide should be applied in the proper concentration and amount at the right time to the right place, and the coverage should be adequate. The addition of certain materials, not primarily insecticidal in themselves, to the insecticide may increase its efficiency. Spreaders and stickers make sprays more effective. Soap increases the toxicity of nicotine sulfate, and

[1] Conn. Agr. Expt. Sta. Bul. **455**, 1942.

Lethane increases the toxicity of derris or cubé. In dust mixtures an improper diluent may cause foliage injury, as does lime when mixed with cryolite, or may decrease the toxicity of the insecticide, as do certain clays when mixed with rotenone-bearing materials.

Bearing in mind what has been said above about control at high levels, if the supply of insecticides is limited it would probably be better in most cases to reduce the concentration of insecticides and treat all plants than to maintain the high concentration and cover only part of the field or orchard. The decrease in control attained by a considerable reduction in concentration may not exceed 10 per cent, and care in application and the use of adjuvants may compensate for part of this. For example, Turner in 1942[1] carried out an experiment for the control of the Mexican bean beetle using ground derris root (4.0 per cent rotenone) diluted with pyrophyllite. The reduction in the number of larvae per plant with a 1 per cent rotenone content dust was 99.7 per cent; with a 0.5 per cent dust, 99.3 per cent; with a 0.25 per cent dust, 98.9 per cent; with a 0.125 per cent dust, 88.6 per cent, and with a 0.0625 per cent dust, 69.9 per cent. The results of laboratory and field tests of insecticides for the control of the European red mite reported by Garman and Townsend (page 235) show the same phenomenon.

If the grower utilizes available information about the ecology of insect pests, the degree of control necessary to obtain a good crop, the measures which may supplement the use of insecticides and the economical use of these insecticides, we feel confident that the obstacles presented by any shortage of spray and dust materials may be overcome.

Work of the Department

The work of this Department falls into two categories: (1) inspection, quarantine enforcement and control operations, and (2) research. As a necessary adjunct to all this, we attempt to maintain a general survey of insect conditions in the State and to inform the citizens about the injuriousness of noxious insects and the means of controlling them. This latter necessitates a large amount of identification work and correspondence, and some travel. There is also an appreciable demand for speakers at meetings of agricultural societies, garden clubs, etc. Although the Department functions mainly in the field of agriculture, innumerable insects are pests of foods, stored products, fabrics and wood structures, are injurious to health, or are simply intolerable nuisances. Occasionally the trouble is purely imaginative, and such cases are difficult to handle.

Nursery inspection (page 214) was carried out as usual during the summer months. The number of nurseries in the State decreased somewhat, and a further decline will probably occur as long as the war lasts. Quarantine enforcement (page 217), which necessitates much plant and other inspection, is concerned with the Japanese beetle, gypsy moth, Euro-

[1] In press.

pean corn borer, Dutch elm disease, white pine blister rust, and the shipment of plant products to foreign countries. No particular difficulty was experienced in this work.

The inspection of apiaries (page 220) has assumed more importance since this country entered the war. Bees play a very significant, though inconspicuous, role in the production of crops by virtue of their activity in pollinating flowers, and the war has increased the demand for honey and beeswax. Our inspectors, all expert beekeepers, not only function in suppressing bee diseases but also furnish information about the keeping of bees whenever this is requested. The number of colonies inspected in the State increased from 10,720 in 1941 to 13,777 in 1942.

There are three pest control operations now being carried on under the direction of this office: gypsy moth control, Dutch elm disease control and mosquito control. The gypsy moth control operations (page 222) are being restricted by a shortage of men. The present crew is about one-third the normal strength. Fortunately, the infestation in 1942 was the lowest known in Connecticut since 1924. No forest areas suffered from defoliation by this pest. The Dutch elm disease problem (pages 219 and 278) is more acute. Eradication of this disease from the State no longer appears within the realm of practicability, and our efforts must be devoted to reducing its injuriousness and restricting its spread (see Figure 12). The federal Bureau of Entomology and Plant Quarantine is also extensively engaged in gypsy moth and Dutch elm disease control work in this State. The cooperation between the Bureau and this Department has always been excellent.

The Director of this Station is Chairman of the State Board of Mosquito Control, and the State Entomologist is fiscal agent of the Board. The report of the mosquito control work (page 225) is published here as a matter of convenience. The lack of available seasonal labor has made the work of maintaining ditched marshes quite difficult, but no serious outbreaks of salt marsh mosquitoes have occurred.

This Station cooperates with the Fish and Wildlife Service of the U. S. Department of the Interior in rodent control work (page 228). We are particularly interested in the mouse control problem in orchards and in rabbit repellents. These mammals are frequently quite injurious to woody plants, and at times to certain crops.

The research work of the Department has always stressed efficient protection against insect pests as its main objective. Under the present conditions, when every piece of equipment, every pound of material and every hour of labor have an enhanced value in production, and production must be not only greater but more efficient, this objective does not change; it receives increased emphasis.

The so-called biological control of insect pests, that is, the utilization of insect parasites and predators and fungous and bacterial diseases, has been an important phase of our work for some time. Particular attention is being given to the parasites of the oriental fruit moth and Comstock's mealybug, both pests of orchard fruits, and to the bacterial "milky" disease of the Japanese beetle (page 231). Of interest in this field is the effect of sulfur sprays on the population of the European red mite on apple trees (page 237). The new Britton Laboratory (frontispiece) contains two work rooms, four air-conditioned breeding rooms and three cold storage rooms where this work is carried on. This laboratory was named after Dr. Wilton E. Britton, former State Entomologist.

The control of insect pests is always an acute problem facing the fruit grower. Better methods and insecticides are being developed every year. Recently "dinitro" compounds have attracted attention and appear promising for the control of certain pests (page 232). New stickers are particularly important at this time because the use of such materials may result in a saving of insecticides and labor (page 237). The life cycle and habits of the red-banded leaf roller, at times a serious apple pest, have been investigated (page 241).

The control of the European corn borer, if intelligently carried out, necessitates an understanding of the relation of its injuriousness to the fluctuations in its population density. Mr. A. M. Vance, of the federal Bureau of Entomology and Plant Quarantine, has made an important contribution to this problem (page 248).

The injuriousness of certain pests of vegetables may be directly related to the date on which the crops are planted. This appears to be the case with the squash vine borer (page 266).

The efficient use of insecticides is, as mentioned previously, a very important problem and one to which the Department has made significant contributions. The relative effect of different doses of insecticides on both insect mortality and crop yield is important in any insect control work. Two aspects of this problem, the relation of the number of insects to damage to plants (page 268), and the effect of dosage on field control (page 272), are discussed in this report. The relation of dosage to control has a very significant application at this time when the supply of chemicals is limited.

The Japanese beetle continues to spread and increase in abundance throughout the State (page 277). In some towns the trees, shrubs and garden plants have been conspicuously defoliated by the adult beetles, and the larvae have seriously injured lawns and golf courses. The causal organism of the "milky" disease of the larvae is being distributed as rapidly as possible (page 231).

The investigations of the elm bark beetle problem in relation to the Dutch elm disease are being continued. The rapidity of spread of the disease is being studied in a series of sample plots laid out across the State, and the incidence of infection has been determined in four towns in Fairfield County (page 285). The value of certain repellents to bark beetle breeding has been determined (page 287). Preliminary tests of the relation of the incidence of twig crotch feeding by bark beetles to the occurrence of beetle breeding material have been conducted (page 290). The effect of winter temperatures on the survival of hibernating larvae of the European elm bark beetle has an important bearing on the spread of the Dutch elm disease. The lethal effect of low temperatures on these larvae has been the subject of investigation for three years (page 291).

The abundance of our important insect pests fluctuates from year to year. In 1942 the rosy aphid of apple was very abundant and seriously injurious to many susceptible varieties, particularly Cortland, Baldwin, Greening and Gravenstein. The European red mite was abundant in many apple orchards early in the summer and caused bronzing of the leaves, but the infestation declined later in the season. The apple maggot was as abundant and injurious as usual. The codling moth was reported to be more abundant than usual in southwestern Connecticut, but we do not experience in this State the extremely severe fruit injury which occurs in many other parts of the country. Comstock's mealybug has increased in abundance in apple and pear orchards in southwest and central Connecticut but is still of minor importance in most orchards. The curculio infestation on apples was noticeably light. The Japanese beetle seriously infested grapevines and injured some of the peach crop, particularly by spreading brown rot. The pear psylla was somewhat injurious, particularly to unsprayed orchards.

Among vegetable crop pests the corn borer infestation was quite severe locally, particularly on early corn. The second generation of the borer was not so bad. Cutworms were very abundant, and the cabbage looper infestation was heavy. The Mexican bean beetle was more abundant than usual. The cabbage maggot was, as usual, injurious locally. The squash vine borer, potato flea beetle, and striped cucumber beetle were moderately injurious, and the aphid infestations were light.

The elm is our most valuable shade tree, and its protection from insect pests has always demanded attention. Elm leaf beetles and fall cankerworms were very abundant in parts of the State in the spring and summer, and many trees were defoliated. The elm lacebug was very abundant in western Connecticut during late summer, and in Litchfield County the leaves of many young trees were conspicuously bronzed.

Many insect specimens are sent to this office each year with requests for information about their injuriousness and control. These are by no means always examples of important agricultural pests, many of them being more significant to the householder and small gardener. A classified list is given below. We also identify numerous specimens sent in by collectors.

Summary of Specimens Received, 1942

Fruit pests	35
Field and vegetable crop pests	23
Forest and shade tree pests	132
Timber and wood products pests	51
Pests of shrubs and vines	20
Flower garden and greenhouse pests	27
Household and stored grain pests	88
Soil and grassland pests	46
Pests annoying man and domestic animals	23
Parasitic and predaceous insects	21
Miscellaneous	27
	493
Species identified for collectors	64

Species Received Five or More Times, 1942

	Times Received
Black carpet beetle, *Attagenus piceus* Oliv.	21
Japanese beetle, *Popillia japonica* Newm.	16
Elm leaf beetle, *Galerucella luteola* Müll.	13
Termite, *Reticulitermes flavipes* Koll.	12
Spruce mite, *Paratetranychus ununguis* Jacobi	12
Eastern spruce gall aphid, *Adelges abietis* Linn.	8
Carpenter ant, *Camponotus herculeanus pennsylvanicus* DeG.	8
Long-horned beetle, *Phymatodes variabilis* Fabr.	7
Oriental beetle, *Anomala orientalis* Waterh.	6
Pine leaf scale, *Chionaspis pinifoliae* Fitch	5
Hickory borer, *Cyllene caryae* Gahn.	5
Buffalo carpet beetle, *Anthrenus scrophulariae* Linn.	5
Clover mite, *Bryobia praetiosa* Koch.	5
Brown dog tick, *Rhipicephalus sanguineus* Latr.	5
Tulip tree scale, *Toumeyella liriodendri* Gmel.	5

In addition to the reports of the work covered here, members of the staff publish scientific bulletins and journal papers which give the most significant results attained. A list of these publications, as well as popular articles on insect pests, may be found on pages 310 and 311.

INSPECTION OF NURSERIES, 1942

M. P. Zappe

The annual inspection of nurseries, as required by Section 2136 of the General Statutes, began on July 1, 1942. The regular force of nursery inspectors, Messrs. A. F. Clark, W. T. Rowe, R. J. Walker and the writer, inspected all the larger nurseries during July and August. The smaller ones were inspected in September. Mr. L. A. Devaux assisted in the inspection of the smaller nurseries, particularly those in the vicinity of New Haven. The work was completed on September 18.

The nursery business was better in the spring of 1942, and it usually follows that when business is good, the nurserymen spend a little more time and effort in keeping their stock in better condition. Some of the smaller nurseries, however, were in poor condition due to neglect.

In order to conserve gasoline and tires the nursery inspectors did not attempt to return to New Haven each night but stayed in the field from Monday through Friday. This enabled them to do more in the field each day and, consequently, the inspection was completed on September 18 this year instead of October 1, as is usually the case.

About 43 different insect pests and seven plant diseases were found during the inspection period. Many of these were not of a serious nature, and only those that required some form of treatment were recorded. In 126 nurseries no pests were found that required treatment. Of the scale insects, oyster-shell scale was the most abundant, and pine leaf scale second. Spruce gall aphids, *Adelges abietis* and *Adelges cooleyi*, on Norway and blue spruces, respectively, were quite abundant. European pine shoot moth was less abundant than in 1941, probably because some nurserymen are not growing mugho pines in such large quantities as they once did. The same is true of red pines. Both species are subject to infestation by pine leaf scale which is becoming a major pest of ornamental pines in Connecticut. The larger number of uninfested nurseries (126) noted this year is due to the fact that we no longer record minor pests and fungous diseases that cannot be transported and for which no treatment is required. Table 1 gives the number of nurseries infested by the more common pests during the last 10 years.

TABLE 1. TEN-YEAR RECORD OF CERTAIN NURSERY PESTS

Pest	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942
Oyster-shell scale	78	104	93	87	84	53	49	57	77	68
San José scale	13	19	17	11	8	2	1	2	7	4
Spruce gall aphids[1]	231	244	285	337	306	312	216	231	227	210
White pine weevil	61	67	98	82	101	97	93	70	61	27
Pine leaf scale	46	66	42	72	60	25	50	48	46	23
European pine shoot moth	137	120	121	108	128	130	110	108	106	54
Poplar canker	34	39	28	28	26	20	14	15	15	11
Pine blister rust	11	7	2	0	4	5	3	3	4	0
Nurseries uninfested	22	21	16	26	25	32	19	33	32	126
Number of nurseries registered	362	381	372	380	377	402	399	376	356	331

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

One of the regulations under which peach stock may be grown in Connecticut nurseries is that there shall be no chokecherries growing within 500 feet of any block of such stock. This means a careful selection by the nurseryman of a suitable field before the peach pits are planted. This area must be kept free from chokecherries during the period that the peach trees are on the land. At least two inspections are made by our staff to see that there are no chokecherries present, and no sign of the peach X disease on any of the peach trees. Only three nurserymen are now growing peach stock. For several years no disease has been found on trees grown under these conditions.

The list of nurserymen for 1942 contains 331 names, a decrease of 25 since 1941. A classification of nurseries by size is given in Table 2. A total of 4,649 acres of land were devoted to the growing of nursery stock in 1942.

TABLE 2. CLASSIFICATION OF NURSERIES BY AREA

Area	Number	Percentage
50 acres or more	16	5
10 to 49 acres	46	13
5 to 9 acres	32	10
2 to 4 acres	81	25
1 acre or less	156	47
	331	100

The list of Connecticut nurseries varies from year to year. Some of the smaller nurseries are carried merely as side lines to other businesses, their number depending upon the time owners have to devote to the business. This year several of the smaller nurseries have been discontinued because the owners have either joined the United States armed forces or are employed in other forms of work connected with the war effort. The acreage also varies from year to year, some nurseries being increased in size while others are decreased. This year several nurseries near cities have been cut up into building lots for real estate developments, and others have sold off a portion of their land for this purpose.

Some of the nurserymen failed to register before July 1, 1942, and, as required by Section 2137 of the General Statutes, were charged for the cost of inspection. Eleven nurserymen have paid the cost of inspection, and $80.00 has been turned over to the treasurer of the Station to be sent to the State Treasury. The nurserymen who failed to pay the cost of inspection, and those who failed to clean up their insect and fungous 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 pests had been properly eradicated, was approximately $1,953.25. exclusive of traveling expenses.

Other Kinds of Certificates Issued

During the year, 187 duplicate certificates were issued to Connecticut nurseries to be filed in other states. Eighty-two dealers' certificates were issued to nursery dealers who do not grow the nursery stock they sell. All this stock is purchased from certified nurseries for resale. Shippers' permits to the number of 427 were issued to out-of-state nurserymen to ship nursery stock into Connecticut. Also, 262 parcels of nursery stock and other plant material were inspected and certified for shipment to accommodate individuals. Four hundred and twenty-seven blister rust control area permits were issued and 2,396 permits for shipments of shelled corn and other seeds, most of which were consigned to foreign countries, chiefly to South and Central America.

Inspection of Imported Nursery Stock

Foreign nursery stock enters the United States at designated ports of entry under permits issued by the federal Bureau of Entomology and Plant Quarantine, and is released for transit to destination points where it is examined by state inspectors. In the past, Connecticut florists imported large amounts of rose stocks for grafting purposes. At the present time rose stocks are grown on the West Coast and growers of roses in the East have been using the western rose stocks in increasing numbers. During the season of 1941-42 no foreign rose stocks were received by Connecticut growers, probably due to the war and scarcity of shipping space on boats.

The following shipments of miscellaneous plants and seeds entered Connecticut during the year. This material is allowed entry into the United States in small lots under a special permit issued by the Bureau of Entomology and Plant Quarantine. All this material is sent to Washington, D. C., where it is inspected by federal inspectors and reshipped to its final destination. None of these shipments were inspected by state inspectors.

101 rhubarb roots
48 perennial plants
34 miscellaneous shrubs
8 dahlia tubers
54 test tubes and flasks of orchid seedlings
24 Alstroemeria tubers
2 bushels of palm seeds
933 pounds of miscellaneous seeds

QUARANTINE ENFORCEMENT, 1942

M. P. Zappe and L. A. Devaux

Since the establishment of the Japanese beetle and gypsy moth quarantines in Connecticut, this Department has cooperated with the federal Bureau of Entomology and Plant Quarantine in administering the quarantines.

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 includes Hartford, Middlesex, New London, Tolland and some towns in eastern Litchfield and New Haven counties. It is under the supervision of Mr. H. N. Bartley, in charge of the federal Japanese beetle and gypsy moth office at Waltham, Mass., whose inspectors make the necessary inspections to comply with the quarantines. The balance of Litchfield and New Haven counties outside of the gypsy moth quarantine area, and the towns of Branford and North Haven in the gypsy moth area, are under the supervision of Mr. M. P. Zappe, in charge of the New Haven office. Fairfield County is under the supervision of Mr. L. Wolfe, in charge of the federal Japanese beetle office at New York, N. Y.

Japanese Beetle

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

Scouting

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 firms to be scouted, the procedure for the year 1942 was changed, in that the district inspectors instead of the usual scouting crews performed the scouting activities.

The section of the State under the supervision of the Waltham, Mass., office was scouted by Mr. R. L. Emrick of Manchester, Conn., Mr. D. Harrington of Westerly, R. I., and Mr. J. F. McDevitt of Middletown, Conn. They began scouting on July 6 and finished on September 16, 1942. The area under the supervision of the New Haven office was scouted by Mr. L. A. Devaux, who began on July 13 and finished on August 26, 1942. There were no classified firms in Fairfield County that required scouting.

In all, nine nursery, greenhouse or other similar establishments and their subdivisions, a total of 15 units, were scouted three to five times. The minimum distance examined around each establishment was 500 feet. A total of 47 adult beetles was found on five of the units scouted. The premises of three dealers in sand, soil and manure were scouted, and 27 adult beetles were found on one of these establishments. Two woodland areas were found to be free from infestation.

The three firms under the supervision of the New Haven office were removed from the classified list as premises of all were found to be infested, with no sections left for possible Class I status.

Beetles were found in Plainville for the first time and a report was received from Brookfield, thus making a total of 89 towns now known to be infested. There are probably many more that have not come to our attention.

Inspection and Certification

The total number of plants inspected and certified for shipment to other states and foreign countries was 2,756,840.

The number and kinds of certificates issued are shown in Table 3.

Table 3. Number of Certificates Issued, 1942

Kind	Farm products	Cut flowers	Nursery and ornamental stock	Sand soil	Manure	Total
"A"	0	0	3,623	1	0	3,624
"B"	0	0	4,389	0	0	4,389
Total	0	0	8,012	1	0	8,013

No inspections of farm products materials and cut flowers were made because no towns in Connecticut were within the area which required 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, occasionally scouting of certain areas in order to issue the necessary certificates, and other tasks necessary to the operation of the quarantine.

Inspection and Certification

The total number of plants inspected and certified for shipment to points outside of the quarantined area was 619,403. Forest products inspected and certified totalled 1,827,559. Stone and quarry products amounted to 2,702½ tons, 1 carload and 196 pieces. Evergreen products totalled 5,930 bales and 102 pieces.

The number and kinds of certificates issued are shown in Table 4.

TABLE 4. NUMBER OF CERTIFICATES ISSUED, 1942

Kind	Nursery stock	Forest products	Stone and quarry products	Evergreen products	Total
"A"	1,179	226	24	70	1,499
"B"	1,569	663	67	79	2,378
Total	2,748	889	91	149	3,877

European Corn Borer

Inspection for the European corn borer to certify shipments to 32 states and Canada was discontinued by the federal government and this work was taken over by the Experiment Station at New Haven. A total of 84 inspection tags was issued to certify such shipments.

Dutch Elm Disease

The federal and state Dutch elm disease quarantines effective in the fall of 1941 prohibit the movement of elm trees and any elm wood bearing bark from the quarantined area to points outside. This created no great hardship on nurserymen or others as there is normally very little movement of elms from quarantined areas to other parts of the State. Fuel wood may present a problem during the present emergency, but most of this is sold locally and no trouble is expected. That part of Connecticut now under quarantine is stippled on the map on page 279 (Figure 12).

INSPECTION OF APIARIES, 1942

M. P. Zappe

There has been no change in the personnel of the bee inspectors since last year. Mr. W. H. Kelsey works in Litchfield and Hartford counties, Mr. Roy Stadel in Fairfield, New Haven and Middlesex counties, and Mr. Elbra Baker in the eastern third of the State.

This year there were 2,354 apiaries inspected in the State, 132 more than last year, with a total of 13,777 colonies, an increase of 3,057 over last year (see Table 5). The average number of colonies per apiary was 5.85 against 4.8 for 1941. The increase in the number of colonies of bees inspected this year was probably due to sugar shortage. This spring and early summer we received many requests for information from individuals who were considering keeping a few bees to obtain honey for their own needs. All the known apiaries in the State were inspected at least once during the summer and some were inspected twice.

Table 5. Thirty-Three Year Record of Apiary Inspection

Year	Number apiaries	Number colonies	Average no. colonies per apiary	Average cost of inspection	
				Per apiary	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

There was a slight increase in the amount of American foul brood this year. Most of the diseased colonies were found in Fairfield and New Haven counties, and the incidence of disease was higher in these counties than elsewhere. Extent of the disease, by counties, is shown in Tables 6 and 7. These were usually destroyed by burning, but occasionally a hive was treated.

TABLE 6. INSPECTION OF APIARIES, 1942

County	Number of towns	Apiaries Inspected	Apiaries Diseased (Am. f. b.)	Colonies Inspected	Colonies Diseased (Am. f. b.)	Per cent diseased
Fairfield	23	372	65	2,214	161	7.3
Hartford	29	525	29	3,028	53	1.8
Litchfield	26	328	24	1,881	65	3.5
Middlesex	15	139	6	1,070	11	1.0
New Haven	27	303	54	1,940	133	6.9
New London	21	294	33	1,880	43	2.3
Tolland	13	200	5	902	13	1.4
Windham	15	193	8	862	11	1.3
	169	2,354	224	13,777	490	3.6

TABLE 7. SUMMARY OF INSPECTION

	Apiaries	Colonies
Inspected, 1942	2,354	13,777
Infected with American foul brood	224	490
Percentage infected	9.5	3.6
Colonies treated		57
Colonies destroyed		433
Average number of colonies per apiary		5.85
Average cost of inspection	$ 1.18	$ .201
Total cost of inspection, 1942		$2,775.55

Three cases of sacbrood (one each in Fairfield, Tolland and Windham counties).

Total cost of inspection was a little more this year than in 1941. All three inspectors worked the full season, whereas last year Mr. Baker worked only from July 1 to the end of the season. The cost per apiary was slightly more than in 1941, $1.17, against $1.16, but the cost per colony was less in 1942, $.201 against $.239.

FINANCIAL STATEMENT

January 1, 1942—December 31, 1942

Disbursements

January 1 to June 30, 1942:

Salaries	$732.00	
Travel	396.60	
Miscellaneous	1.05	
		$1,129.65

July 1 to December 31, 1942:		
Salaries	$996.00	
Travel	647.45	
Miscellaneous	2.45	
		1,645.90
Total disbursements for 1942		$2,775.55

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 the number of colonies belonging to each registrant.

In 1942, 2,354 apiaries containing 13,777 colonies were inspected. However, only 1,499 apiaries and 9,957 colonies were registered. This shows that 855 more apiaries and 3,820 more colonies were inspected than registered by the town clerks in 1942. No doubt some unregistered apiaries were left uninspected by the apiary inspectors who were unable to locate them. 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.

REPORT ON CONTROL OF THE GYPSY MOTH

J. T. Ashworth

Gypsy moth control work[1] has been carried on in the same manner as in former years. In the spring, infestations were sprayed with lead arsenate to reduce or possibly eradicate the gypsy moth. Infested areas were scouted during the summer months to detect gypsy moth larvae and pupae. In the fall, winter and early spring, trees in the open and woodland were scouted for gypsy moth egg masses, which were destroyed when found. These varied control operations were carried on in 21 towns in Hartford, Litchfield, New Haven, New London and Tolland counties with the cooperation[2] of the federal Bureau of Entomology and Plant Quarantine.

Type-mapping, a description of which will be found in the Connecticut State Entomologist's Report of 1940, was continued, and 13 additional towns in Windham and New London counties were completed.

A rapid survey of Hartford, Litchfield, Middlesex, New London and Windham counties revealed no gypsy moth defoliation.

[1] July 1, 1941, to June 30, 1942.

[2] This cooperation is greatly appreciated, and the writers here express their gratitude to Mr. A. F. Burgess and to his successor in office, Mr. R. A. Sheals, in charge of gypsy and brown tail moth control for the Bureau of Entomology and Plant Quarantine, and to Mr. H. L. Blaisdell, in charge of field operations under them.

Work Performed by State Men

During the year, state men performed work in one form or another in 21 towns in Hartford, Litchfield, New Haven, New London and Tolland counties. They scouted 179½ miles of roadside and 11,104 acres of open country and woodland, destroying 1,216 egg masses and 1,695 larvae and pupae. Spraying operations were carried on in 24 infestations where 5,650 pounds of lead arsenate were used.

Hartford County: The towns of Farmington, Plainville and Rocky Hill were scouted, infestations of gypsy moth being found in all towns. However, none of the infestations found in Plainville were treated except during the spraying season, when five of the seven infestations found were sprayed. During the larval season, Granby, Hartland and Simsbury were patrolled and caterpillars were found at points visited. Spraying operations were carried on at 15 infestations in Farmington, one infestation in Glastonbury, one infestation in Granby, five infestations in Plainville, and one infestation in Rocky Hill. A total of 5,642 pounds of lead arsenate were used in these operations.

Litchfield County: The following towns were scouted in this County: Colebrook, Kent, North Canaan, Salisbury and Sharon. Infestations were found in all towns. A larval scout was carried on in Barkhamsted, Kent, North Canaan, Roxbury, Salisbury and Sharon, and caterpillars were found in all towns excepting Roxbury.

New Haven County: Branford and Southbury were scouted for egg masses and, although no infestation was found in Southbury, a later scout in that town did reveal larvae. The only spraying project in this County was the spraying of a small infestation in Branford where 8 pounds of lead arsenate were used.

New London County: Infestations were found in the towns of Groton, New London and Stonington.

Tolland County: A scout of Stafford revealed four scattered single egg masses.

Work Performed by the Federal Bureau of Entomology and Plant Quarantine

During the year, federal crews carried on control operations in 16 towns in Litchfield and New Haven counties. They scouted 47 miles of roadside and 21,053.5 acres of open and woodland, destroying 705 egg masses and 7,203 larvae and pupae. They also cleared the underbrush from one acre of woodland. They applied 11,054 burlap bands to trees in and around infested areas. Spraying operations with an autogiro were carried on in seven infestations in Canaan, using 37,800 pounds of lead arsenate. This record includes work done by state crews in Kent and Norfolk. This was not a duplication, but work in which state men supplemented the federal men when the latter were not available.

TABLE 8. SUMMARY OF STATISTICS OF INFESTATIONS OF GYPSY MOTH, 1941-42

County	Number of towns worked	Infestations found	Egg masses creosoted	Number colonies sprayed	Lbs. lead ars. used	Larvae, pupae crushed	Bands applied	Miles scouted	Acres scouted	Acres cleaned
Hartford	7	53	789	23	5,642	1,004	0	118.75	163	0
Litchfield	16	95	703	7	37,800	7,746	10,083	27.25	19,580.5	1
New Haven	3	1	5	1	8	79	971	26	5,045	0
New London	3	11	378	0	0	0	0	35.5	0	0
Tolland	1	0	4	0	0	0	0	11	0	0
	30	160	1,879	31	43,450	8,829	11,054	218.5	24,788.5	1

For statistics of gypsy moth infestations, see Table 8.

Brown-Tail Moth Control

There was no brown-tail moth scouting project carried on in Connecticut during the 1941-42 season.

MOSQUITO CONTROL

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

Mosquito control work[1] in Connecticut under authority of the General Statutes, Sections 2415 and 2416, is mainly routine work consisting of maintaining about 11,000 acres of legally accepted salt marsh areas free from mosquito breeding.

It will be recalled that the expenses of the original ditching systems installed between 1912 and 1929 were paid for by private subscriptions and town-voted funds. The mosquito nuisance in coastal areas and for some distance inland had been unbearable. The work is maintained under a law, revised in 1923, making such maintenance a state obligation. Uniform control has thus been made possible, as the state funds can be expended where the work is most needed.

It must be remembered that there are yet 7,000 acres of salt marsh areas ditched but not maintained by the Board, and these may be supplying some of the mosquitoes found in the maintained areas. Mosquitoes are also breeding as usual in fresh water swamps, ponds, temporary pools, sluggish streams and various unthought-of receptacles, which, if left untreated, may tend to nullify the work of the Mosquito Board. Even though state funds cannot be used to treat such areas, an inspector may examine any potential breeding area and give advice concerning its treatment. Any mosquito-breeding place is defined by law as a public nuisance and must be eliminated when so ordered by the local health officer.

Anopheles mosquitoes are quite common in Connecticut and, with the present movements of military and industrial personnel, the chances of a malaria epidemic are much increased. It is important, therefore, to treat swampy areas, spring holes, and the edges of streams where Anopheles mosquitoes breed. This not only prevents the nuisance of the ordinary pest mosquitoes, but may insure local immunity from a malaria epidemic.

The statutory work of maintaining the ditching systems on the 11,000 acres of accepted salt marshes began early in March this season, due to the mild weather, and continued until December 31. Fortunately, all of the men who had returned regularly each season were again on hand this spring. The crews were nevertheless very small because of the scarcity of labor and by midsummer only five men were working besides the permanent staff. The areas were covered rapidly, however, due to the fact that large crews on the work last season had put the ditches in excellent condi-

[1] The control of mosquitoes is carried out under a State Board of Mosquito Control and is not a function of the Agricultural Experiment Station. This report is published here as a matter of convenience.

tion. Mosquitoes emerged in some areas, but not in sufficient numbers to create a serious nuisance. The conditions in these areas were immediately improved and mosquito breeding ceased.

Frequent rains caused many potential breeding areas, as also did dams in ditches made by haying crews for crossings and careless dumping of waste. Many of the shore cottages were occupied by munition workers who were not familiar with the function of the ditching system and used the nearest ditch for rubbish disposal. Considering the wet season, however, very few complaints of mosquito nuisance were received.

Stamford areas were readily put in good condition with the exception of an area near Doane's Boat Yard. Breeding occurred there, and new ditches were required, also much cleaning work on old ditches and the main drainage creek.

Norwalk areas were all patrolled in the season and all areas treated by cleaning ditches or oiling. Breeding was persistent at the city disposal plant. Ditches were improved and areas which could not be drained in time to stop emergence were sprayed with oil. Some oil was contributed from filling stations, and some purchased by the City. Areas at Manresa Island, Crescent Avenue and at Calf Pasture Beach were oiled.

Westport has one serious breeding area at Saugatuck Shores, due to an iron pipe drain rusting away and becoming useless. This area was sprayed with oil contributed by the land agent. The ditches were cleaned and graded in all areas where necessary.

Fairfield contains many areas where it is extremely difficult to prevent damage to the ditching systems, and in some areas mosquitoes were a nuisance. Most of these violations are caused by careless dumping of rubbish which cut off drainage, by deliberate filling of ditches for foot crossings and by dams made by children. The tidegate outlet at Fairfield Beach became clogged and flooded the swamp area. This was relieved before breeding occurred, but the pipe could not be entirely freed of the obstruction.

West Haven areas under state care were well maintained and no breeding was observed. The town of West Haven had apparently maintained the balance of the salt marsh areas and fresh water areas also.

New Haven, Hamden and East Haven salt marsh areas were completely patrolled and maintained in good order. There was no breeding of any consequence.

Branford and Guilford required considerable work, consisting of cleaning ditches and outlets. All ditches in the East Creek area of Guilford require cleaning every year.

The leak under the sill of the Branford River tide gate on Montowese Street was partially sealed with stones by a contractor. The leak was so bad that several truckloads of stones, some weighing two tons, were required to close the opening. All nine gates should be replaced with new ones as soon as possible. Two new gates were built and installed at the Great Harbor dike. The dike itself, left unfinished by the W.P.A., is being washed away by the high tides. A nearby property owner was hired to rebuild a stone protecting wall but, due to scarcity of labor, this could not be completed.

Madison, Clinton, Westbrook and Old Lyme could not be completely covered and maintained this season due to the labor shortage. Mosquito breeding did not become serious, however, because the small crew was moved quickly to the areas threatened and the necessary corrections made. A new culvert was installed at the foot of Waterside Road, Clinton, to drain a very bad area between the public beach and the road. Very careful grading was done to drain a low area east of Harbor View, Clinton.

At the request of the Superintendent of the Board of Fisheries and Game, a special type of tide gate was built and installed on Great Island to provide a controlled water area for wild fowl. This work is experimental and will require some observation and trial before success can be assured.

Groton and Stonington could not be patrolled this season because suitable labor could not be obtained, and the distance from New Haven is too great to make daily trips. The ditches were not in bad condition, however.

Random collections of mosquito larvae were brought into the laboratory for rearing and identification, and the following species were identified:

Aedes cantator	Westport Norwalk Fairfield
Culex pipiens	Norwalk Westbrook Branford
Culex territans	Old Lyme Branford
Aedes triseriatus	Hamden Branford
Aedes taeniorhynchus	Norwalk
Aedes sollicitans	Stamford East Haven
Aedes vexans	Fairfield
Aedes canadensis	Westport

RODENT CONTOL

F. B. Schuler, Agent

Fish and Wildlife Service, U. S. Department of the Interior, cooperating with the Connecticut Agricultural Experiment Station

Further investigations on the control of injurious rodents have been made. These were mainly concerned with the ecology and control of the meadow mouse, *Microtus pennsylvanicus,* and with checking the effectiveness of various repellents to protect trees and shrubs against cottontail rabbits, *Sylvilagus transitionalis* and *Sylvilagus floridanus mallurus.*

Meadow Mouse

A population survey was conducted in May, 1942, throughout the northeastern states. The Connecticut survey indicated that the mice had maintained a large breeding stock through the winter, and a large population should be expected this fall. A report from all the northeastern orchard belt indicated that the populations had fallen off in the northernmost sections, but were on the increase from southern Massachusetts southward.

Conditions were unfavorable for mice in 1939 and as a result the populations were low. During 1940 there was a definite though not a large increase in the population. This built up considerably during the spring and early summer of 1941, but was radically checked by the late summer drought. As a result distribution was spotted, although there were high populations in the best cover.

Through the survey made in September, 1942, it was found that meadow mice have increased to such an extent that they trebled in number the previously recorded high. Conditions have been favorable for the meadow mouse since early spring. The ideal growing season resulted in heavy stands of cover crops in all sections of the orchards. As a consequence, the existing population is uniform and very dangerous.

Control tests are now being conducted with formulas of new zinc phosphide-treated steam-crushed oats. It is hoped that these new mixtures will prove even more efficient than those now in use.

Rabbit Repellents

This study has developed in two closely related phases, (1) testing repellents prepared by the Research Laboratory under pen conditions and (2) field studies of adhesives that may be used in the repellents.

Twenty wild cottontail rabbits, *Sylvilagus transitionalis,* and *S. floridanus mallurus,* were trapped for use in the pen studies. One rabbit was used in each ground pen. The procedure used was the same as that stated in the 1941 report, with the exception that in late April the rabbits were transferred to wire-floored pens. This was necessary because of the succulent vegetation growing in the ground pens.

The following repellents were tested:

R 1	Rezyl No. 53, ethylene dichloride
R 2	Asphalt emulsion, ethylene dichloride
R 3	Asphalt emulsion, Rezyl No. 53, ethylene dichloride
R 4	Ebonal, ethylene dichloride
R 5	Rezyl No. 53, ethylene dichloride, copper carbonate
R 6	Rezyl No. 53, ethylene dichloride, dry lime sulfur
R 7	Rezyl No. 53, ethylene dichloride, dry lime sulfur, copper carbonate
R 8	Permatex A (concentrate)
R 9	Rezyl No. 53, ethylene dichloride, Pestex
R 10	Rezyl No. 53, ethylene dichloride, ACCO repellent
R 11	Rezyl No. 53, ethylene dichloride, 80 per cent free nicotine
R 12	Rosin (powdered), ethyl alcohol
R 13	Asphalt emulsion, 25 per cent alcohol, ammonium thiocyanate
R 14	Asphalt emulsion, ethylene dichloride, copper carbonate
R 15	Rezyl No. 53, asphalt emulsion, ethylene dichloride, copper carbonate, dry lime sulfur
R 16	Rezyl No. 19, asphalt emulsion, ethylene dichloride, copper carbonate, dry lime sulfur
R 17	Rezyl No. x315, asphalt emulsion, ethylene dichloride, copper carbonate, dry lime sulfur
R 18	Asphalt emulsion, methyl alcohol, copper carbonate
R 19	Unknown mixture
R 20	Rosin, ethyl alcohol (6 pounds to 1 gallon)
R 21	Asphalt emulsion, water, Black Leaf 155, (nicotine 14 per cent)
R 22	Rosin, asphalt emulsion, ethylene dichloride, copper carbonate, dry lime sulfur
R 23	Asphalt emulsion, water, DuPont product No. 15
R 24	Asphalt emulsion, water, DuPont product No. 16
R 25	Asphalt emulsion, water, DuPont product No. 17
R 27a	Rosin emulsion, water, dicalite, Black Leaf 155
R 27b	Dowax, water, Black Leaf 155
R 27c	Asphalt emulsion, water, Black Leaf 155
R 27d	Rezyl-asphalt emulsion, ethylene dichloride, Black Leaf 155
R 27e	Lanolin emulsion, Black Leaf 155
R 28	Rezyl No. 19, ethylene dichloride and paradichlorobenzene
R 31	Rezyl No. 53, ethylene dichloride and rattlebush bean (*Daubentonia drummondii*)
R 32	Asphalt emulsion, water and calcium lignin sulfonate
R 33	Asphalt emulsion, water and potassium alum
R 34	Asphalt emulsion, water and potassium amyl xanthate
R 35	Asphalt emulsion, water and "El Sixty"
R 36	Asphalt emulsion, water and "A-1" accelerator
R 37	Asphalt emulsion, water and "Ceresan"
R 38	Q. S. R. Bases, Koppers Co.
R 39	Rosin, ethylene dichloride and naphthalene flakes
R 40	Asphalt emulsion, water and copper sulfate
R 41	Asphalt emulsion, water and Bordeaux mixture
R 42	Asphalt emulsion, water and Acme fish oil soap
R 43	N N O P, water (Atlas Powder Co.)
R 44	N N O P, water (Atlas Powder Co.)
R 45	Rosin emulsion, water, dicalite, Nicofume (free nicotine)
R 45a	Dowax, water, dicalite, Nicofume
R 45b	Asphalt emulsion, water, dicalite, Nicofume
R 45c	Rezyl-asphalt emulsion, ethylene dichloride, dicalite, Nicofume
R 45d	Lanolin emulsion, dicalite, Nicofume
R 46	Rosin emulsion, water, ammonium sulfamate
R 46a	Asphalt emulsion, water, ammonium sulfamate

Some of the repellents tested in the past were checked again this year. It is desirable that the minimum amount of repelling substance necessary for adequate control be ascertained. This was one reason for these rechecks. In each test run five rabbits were used.

After a number of test runs had been made, the best repellents in the group were rechecked. The inclusion of the four best repellents of a number of tests in a recheck test served to eliminate the possibility of inadequate competition among the repellents of a group. It also definitely eliminated the inferior mixtures. Ten rabbits were used in each recheck test in order to reduce the possibility of recording only individual preference. As indicated in the summary, repellents R 15, R 16 and R 31 were most effective.

As an indication of the feeding pressure during the tests, the rabbits fed on sumac, gray birch, red and white oak, hickory, red maple, aspen and raspberry. Many of these plants are seldom accepted as food in the wild. To help maintain vigor the rabbits were fed a small handful of prepared rabbit ration, and an apple as they required it.

Summary of Tests

Symbols: RC Recheck test W On wire-floored pens

Tests	Repellents listed in order of effectiveness
1	R 4, R 1, R 2, R 3
2	R 7, R 6, R 8
3	R 11, R 9, R 10, R 13
4	R 15, R 16, R 12, R 14
5	R 17, R 21, R 19, R 20
6	R 23, R 22, R 24, R 25
7	R 33, R 35, R 32, R 34
8	R 41, R 36, R 37, R 42
9	R 18, R 31, R 40, R 28
10-W	R 27d, R 27a, R 27b, R 27c
11-W	R 45c, R 45, R 45a, R 45b
12-W	R 27e, R 45d, R 46, R 46a
RC 1	R 15, R 4, R 7, R 11
RC 2	R 16, R 7, R 21, R 25
RC 3-W	R 31, R 38, R 41, R 43

Adhesive Study

During February and March various adhesives were applied to young dormant apple trees. The first set of adhesives were painted on five young trees of various varieties. Each adhesive in the second group was applied to two young trees.

The plots were checked monthly for the first three months after application; later this was reduced to a quarterly reading. The adhesives were graded as excellent, fair or poor, depending on their resistance to weather and the effect on the trees.

To date the most promising adhesives from the weathering standpoint are A-7 and A-20. Cost, availability and other factors are not considered in this evaluation. A list of the adhesives follows:

A 1	Asphalt emulsion, ethylene dichloride
A 2	Asphalt emulsion, water
A 3	Rezyl No. 53, asphalt emulsion, ethylene dichloride
A 4	Rezyl No. 53, ethylene dichloride
A 5	Ebonal, ethylene dichloride
A 6	Rezyl No. 315, ethylene dichloride
A 7	Rezyl No. 19, ethylene dichloride
A 8	Bakelite XR14987, ethylene dichloride
A 9	Paraffin emulsion, dicalite, tracer, water
A 10	Polyvinyl acetate, emulsion, starch paste, dicalite, tracer
A 11	Bentonite, dicalite, tracer, water
A 12	ML Casein, dicalite, tracer, water
A 13	Rosin, ethyl alcohol, dicalite, tracer
A 14	Casco glue, dicalite, water, tracer
A 15	Rezyl No. 53, ethylene dichloride water emulsion, dicalite, water
A 16	Paraffin water emulsion, dicalite
A 17	Rezyl No. 19, ethylene dichloride, whiting, tracer
A 18	Rezyl No. 53, ethylene dichloride, whiting, tracer
A 19	Rezyl No. 53, ethylene dichloride water emulsion, asphalt emulsion, dicalite
A 20	Rezyl No. 53, ethylene dichloride, whiting, copper carbonate, tracer
A 21	Rezyl No. 19, ethylene dichloride, asphalt emulsion, copper carbonate
A 22	Rezyl No. 53, ethylene dichloride, asphalt emulsion, copper carbonate
A 23	Nu-film Rosin emulsion, dicalite, water
A 24	Rezyl x315, ethylene dichloride, dicalite
A 25	Same as R 15
A 26	Same as R 16
A 27	Same as R 17
A 28	Same as R 20
A 29	Same as R 22
A 37	Mannitan monolaurate (NNO), water dicalite
A 38	Dowax, water, dicalite
A 40	Bordeaux mixture, mannitan monolaurate (NNO), water
A 41	Otwell's tree paint, water
A 42	Gum arabic, water, glue, dicalite
A 43	Casein, waterglass, ammonia, glycerine, dicalite
A 44	Kayso, waterglass, water, dicalite
A 45	Soybean flour, alkaline glue, waterglass, dicalite
A 46	Blood albumen, alkaline glue, waterglass, dicalite
A 47	Cottonseed oil—bentonite water emulsion, dicalite
A 48	Corn oil—bentonite water emulsion, dicalite
A 49	Soybean oil—bentonite water emulsion, dicalite
A 50	Inverted oil spray—mineral oil water emulsion, dicalite
A 51	Inverted oil spray—soybean oil water emulsion, dicalite
A 52	Latex emulsion, alkyd 17A (Resin emulsion), water, dicalite
A 53	Alkyd 18A (Resin emulsion), starch paste, dicalite
A 54	Alkyd 18A (Resin emulsion), water, dicalite

REPORT ON PARASITE AND DISEASE WORK

Philip Garman, W. T. Brigham, J. C. Schread and G. R. Smith

Extensive colonization of Japanese beetle milky disease was carried out. One-half acre plots were placed in areas around Hartford and New Haven, with a few in Fairfield County and other localities. In this work 1,260 pounds of spore dust were used and approximately 700 acres of turf were treated. Up to November 1, 1,403 separate properties were treated, mostly one-half acre plots distributed evenly over the infested territory.

The annual checkup of disease-treated experimental plots indicated that they contained many more diseased grubs than a year ago. It is evident from the work so far that the disease starts slowly in Connecticut but is capable of destroying many grubs when well established. As yet, the disease is not abundant enough to reduce the population of Japanese beetles to any noticeable extent. Table 9 gives the incidence of disease in plots established in the summer of 1940.

TABLE 9. PROGRESS OF MILKY DISEASE IN EXPERIMENTAL PLOTS

Location	Grubs per sq. foot of lawn 1940	1941	1942	Per cent of grubs diseased 1940	1941	1942
Bridgeport, Seaside Park (3 plots)[1]	3.8	6.3	6.4	0	0	21.7
Check (3 plots)	3.7	4.8	5.3	0	0	10.2
Hartford, Keney Park (2 plots)		12.5	1.2		10.7	56.6
Check (2 plots)			1.6			6.2
New Haven, East Rock Park (6 plots)	9.5	12.8	2.3	3.1	0.0	27.1
Check (1 plot)			1.8		0.0	16.0[2]
New Canaan, Check area (5 plots)			3.0			0.0

[1] Average of counts by two different investigators.
[2] Type B disease.

Owing to the reduced peach crop in 1942, fewer growers ordered parasites for the oriental fruit moth than in 1941. We received 81 orders and delivered 32,160 adult Macrocentrus parasites. Infestations varied considerably, being worse in some localities than in others. For the most part, however, the crop was clean. An annual checkup on peaches at harvest continued to show low infestations in orchards with high parasitism, and vice versa.

Comstock's mealybug was found in 10 different localities and 11 orchards in the State. It occurred on pears in two of these. This relatively new pest appears to be building up rapidly in some places, but declined this year in the pear orchard where it was first discovered. In that locality parasitism, mainly by *Allotropa convexifrons* Mues., reached 90 per cent, and it was evident that the very great reduction there was largely due to the percentage killed by parasites. Thus far, we have been able through the courtesy of the U. S. Bureau of Entomology and Plant Quarantine to obtain parasites for colonization in four different orchards.

REPORT ON FRUIT INSECT INVESTIGATIONS, 1942

Rosy Apple Aphid

PHILIP GARMAN AND J. F. TOWNSEND

An attempt was made in 1942 to predict whether aphid infestations would be severe or light. Twig collections received from orchardists throughout the State, taken mainly from varieties subject to severe infestations, were held in our greenhouse until leaves and blossoms unfolded and the aphids emerged. It was hoped to obtain useful data for prediction but we learned nothing of value. The performance of aphids and parasites during the previous year taken in consideration with the weather during the period of egg deposition seems to give data for a more accurate prediction than examination of twig collections.

So much depends on May and June rainfall and temperatures that one cannot expect complete success with any known method of prediction. Early cold spells in November (10° F.) are fatal to the adult female. If there should be, besides the cold spell, an increase of natural parasites and predators during the preceding summer, the chances are good the following spring for a light infestation. If, on the other hand, the weather is favorable for fall egg laying, and parasites and predators have become scarce (as when the aphids on which they feed are scarce), then we may certainly look for aphids in abundance to begin a spring offensive.

Field control experiments with sprays (see Table 10) were conducted in three orchards. The effect of oils on dinitro powders was found to be negligible, as far as increasing the kill of dinitro products for aphids is concerned. Likewise, the addition of dinitro powders to oils did not

TABLE 10. APHIS CONTROL, 1942
Sprays applied April 2

Material and dilution per 100 gallons		Per cent aphis apples at harvest
	Variety, Greening	
2,4 Dinitro-phenol	1 lb.	
Waterglass	1 pint	.69
Oleic acid	½ pint	
3,5 Dinitro-o-cresol	1 lb.	
Waterglass	1 pint	1.88
Oleic acid	½ pint	
Check—no aphis spray		6.11
	Variety, Baldwin[1]	
2,4 Dinitro-phenol	1 lb.	
Waterglass	1 pint	12.08
Oleic acid	½ pint	
2,4 Dinitro-phenol	1 lb.	
Waterglass	1 quart	7.93
Oleic acid	½ pint	
Check—no aphis spray		24.17
	Variety, Rome	
Dinitro powder[2] (commercial)	1 lb.	2.8
Dinitro powder (commercial) plus oil, 2%	1 lb.	2.16
Check—no aphis spray		22.04

[1] Large trees—difficult to cover thoroughly.
[2] Guanidine salt of dinitro-o-cresol.

increase the kill of oils for European red mite eggs. Homemade mixtures of 3,5 dinitro-o-cresol and 2,4 dinitro-phenol were compared. These two compounds were first dissolved in waterglass diluted with hot water from the truck radiator. Then a small amount of oleic acid was added just before final dilution. The coverage obtained from this combination appeared to be excellent, and aphis control was good. For each pound of dinitro-phenol or dinitro-cresol a quart of waterglass and ½ pint of oleic acid are required. Lauryl thiocyanate applied at the green tip period, about April 15, gave substantial reductions in aphis apples at harvest. This insecticide appeared to be effective at 1 pint to 100 gallons on medium-sized Cortland trees, but 1½ pints to 100 gallons were required to give satisfactory control on large Baldwins. Results are shown in Table 11.

Table 11. Aphis Control with Lauryl Thiocyanate, 1942

Sprays applied April 17

Material and dilution per 100 gallons		Infested spurs per tree June 7	Per cent aphis apples at harvest
Variety, Cortland			
Lauryl thiocyanate	½ pint	19	6.41
Lauryl thiocyanate	1 pint	27	5.21
Check—no aphis spray		675	23.53
Variety, Baldwin			
Lauryl thiocyanate	¾ pint	—	12.53
Lauryl thiocyanate	1½ pints	—	2.08
Check—no aphis spray		—	16.66

European Red Mite

Philip Garman and J. F. Townsend

Laboratory tests with 3,5 dinitro-o-cresol, 2,4 dinitro-phenol and dinitro-cyclo-hexyl-phenol showed that the winter eggs may be killed with specially prepared solutions of the dinitro compounds. During 1940, field sprayed eggs indicated a very low kill with the compounds as first employed. In these tests the powdered chemicals were placed in water and sprayed on the twigs. It was seen that much of the dinitro preparations remained in suspension and was probably lost. Comparisons of commercial fish oil soap as a solvent and triethanolamine oleate indicated better kills with the oleate, so preparations were then made by dissolving each of the dinitro chemicals mentioned in monoethanolamine and then adding oleic acid equal in amount to the monoethanolamine. In tests with these preparations much better kills of mite eggs were obtained. Similar experiments in 1942 confirmed the 1940 results. From 97 to 98 per cent of the winter eggs were killed with all three of the dinitro products. The dilution was .06 per cent and .18 per cent with approximately half that amount of sodium oleate and monoethanolamine. Table 12 shows the dilution and kill obtained with 2,4 dinitro-phenol.

TABLE 12. LABORATORY TESTS WITH 2,4 DINITRO-PHENOL FOR KILLING EGGS OF THE EUROPEAN RED MITE

1940, Feb. 29—April 6				
Dilution in grams per L. 84% dinitro-phenol	.404	.468	.752	1.42
Dilution of monoethanolamine and oleic acid	.202	.234	.376	.710
Kill of European red mite eggs	46.1%	83.6%	89.0%	95.3%
1942, April 9—May 12				
Dilution in grams per L. 84% dinitro-phenol	.28	.725	2.175	4.524
Dilution of monoethanolamine and oleic acid	.125	.308	.937	1.95
Kill of European red mite eggs	68.8%	97.8%	98.4%	98.4%

During the summer, field tests were conducted with special DN-111, a dicyclohexylamine salt of dinitro-cyclo-hexyl-phenol (Table 13), as well as Xanthone (Table 14), and rotenone (Syntone) preparations (Table 15). The rotenone sprays were tested again this year to learn if any deterioration occurred in the commercial concentrates. None could be detected. One of the most promising summer sprays yet tried was the DN-111. It gave good control except where rain fell within a few hours after spraying (Table 13). DN-111 is compatible with arsenate of lead and possibly other materials. Only slight injury resulted from applications of 16 to 24 ounces to 100 gallons, and this did not permanently affect either fruit or foliage.

TABLE 13. CONTROL OF EUROPEAN RED MITE, 1942
Variety, Baldwin

Material and dilution		Adult female mites per 100 leaves				
		June 24[2]	June 27	July 4	July 13	July 25
DN-111[1]	16 oz.—100 gals.	2,595	52	300	1,016	272
DN-111	20 oz.—100 gals.	3,625	44	228	359	284
DN-111	24 oz.—100 gals.	2,075	21	81	78	114
Check—no red mite spray		3,105	2,012	2,032	1,232	36
		June 16	June 19	June 26	July 7	July 13
DN-111	24 oz.—100 gals.	1,849[3]	623	250	857[3]	10
DN-111	12 oz.—100 gals.	1,458	866	407	786	22
Check—no red mite spray		1,060	1,048	946	1,198	538

[1] Analysis by Dr. H. J. Fisher: %
Gypsum 81.59
Dicyclohexylamine salt of dinitro-cyclo-hexyl-phenol 18.45
[2] Spray applied June 25.
[3] Sprays applied June 16 and July 7. Rain followed spray on July 7.

TABLE 14. CONTROL OF EUROPEAN RED MITE, 1942
Variety, Baldwin

Material and dilution		Adult females per 25 leaves			
		June 18	June 22	June 29	July 14
Xanthone	2 lbs.				
Soap	1 lb.	933	11	34	379
Zinc sulfate	4.5 oz.				
Check—no spray		280	172	131	77

TABLE 15. CONTROL OF EUROPEAN RED MITE WITH ROTENONE SPRAYS, 1942

Applications July 1—Power sprayer from ground with six-nozzle gun approx. 450 lbs. at pump. Sprayed A.M., rain late P.M., temp. 80° F.

Counts of adult females on 20 leaves of each tree

Treatments	Trees	June 30	July 3	July 9	Per cent reduction July 3	Per cent reduction July 9
"Syntone" ½ pint	H 1	186	24	133		
Q oil ½ pint (old stock)	H 2	155	2	20		
Water to make 100 gals.	G 2	220	5	52		
	G 4	191	6	73		
	G 5	192	6	45		
		944	43	323	96.50	65.78
"Syntone" ½ pint	H 2	318	23	61		
Q oil ½ pint (new stock)	H 8	135	2	55		
Water to make 100 gals.	G 1	181	4	39		
	G 3	280	4	58		
	G 8	71	2	29		
		985	35	242	96.44	75.43
"Syntone" 1½ pints	H 4	250	0	20		
Q oil 1½ pints (old stock)	H 6	230	1	14		
Water to make 100 gals.	H 9	190	2	15		
	G 5	449	1	63		
	G 10	83	3	27		
		1202	7	139	99.25	88.43
"Syntone" 1½ pints	H 3	259	3	14		
Q oil 1½ pints (new stock)	H 5	273	0	15		
Water to make 100 gals.	H 10	147	1	29		
	G 6	203	4	63		
	G 9	88	5	18		
		970	13	139	99.69	85.67
Q oil[1] 1 qt. to 100 (old stock)	F 2	99	27	89		
	F 3	126	26	64		
	F 4	172	42	84		
	F 5	168	38	116		
	F 6	121	27	76		
		686	160	429	76.67	37.46
Q oil 1 qt. to 100 (new stock)	I 3	62	23	23		
	I 4	107	29	39		
	1 5	106	17	53		
	I 6	85	5	38		
		360	74	153	79.44	57.50

Factory control number of New Syntone (122 emulsified M 6935, 1942 product).

[1] Dilution of old stock Q oil somewhat uncertain. Probably an error in mixing according to field notes.

In addition to the insecticide tests a running survey of mite populations was made in our Mount Carmel orchards. These counts, Table 16, showed

TABLE 16. EUROPEAN RED MITE POPULATION STUDIES, 1942
Variety, Baldwin
20 leaf samples—adult females

Treatment	Jn. 3	Jn. 11	Jn. 26	Ju. 7	Ju. 16	Ju. 29	Aug. 6	Totals
Sulfur-lime-lead arsenate (five sprays)	76	2,054	1,245	1,052	27	0	0	4,454
No sulfur Oil-aluminum acetate-manganese borate-lead arsenate (three sprays)	116	1,024	419	388	0	2	0	1,949
No sulfur Oil-lead arsenate (three sprays)	139	1,050	408	1,213	51	0	0	2,861
No sulfur Oil-lime-talc-lead arsenate (three sprays)	118	1,114	615	649	387	3	0	2,886

as in previous years a considerably greater population of mites developing in sulfured plots than in unsulfured ones. Similar but more extensive counts were made in the Burton Orchard by Mr. Jaynes of the U. S. Bureau of Entomology and Plant Quarantine and his assistants. These showed the same trend, namely increased populations in sulfured plots and reduced populations in those where sulfur was omitted. Glue and soybean flour (the tests of soybean flour not shown in tables) were added to sulfur sprays without making any significant difference in the mite populations (Table 17).

Stickers and Reduced Spray Schedules

PHILIP GARMAN

Laboratory tests, using 3¼ by 4-inch glass slides and a settling tower for coating them with the sprays, gave some interesting results. These seem to correspond with field tests, but are probably not equivalent to full scale field experiments where the spray is exposed to weathering over a long period. It was learned by this method, however, that a combination of talc, lime and lead arsenate adheres much better than when the lime is omitted. Also, it was learned that alumina and silica gels are unusually good adhesive agents, and it can be readily demonstrated that oils alone are very good.

Field experiments with four different combinations used throughout the season indicate that lead arsenate with oil, talc, and lime or oil, aluminum aceto-formate, manganese borate and benzoic acid remained on the foliage much better than lead arsenate, lime and wettable sulfur. Trees sprayed with lead arsenate and the special aluminum aceto-formate, etc., sticker were in much better condition at the end of the season and the fruit was smoother than that of other blocks except those sprayed with the oil, talc and lime combination. Tests on a smaller scale were made with lime, silica solution,[1] wettable sulfur and lead arsenate, as well as with talc, lime,

[1] Colloidal silica with a small amount of sodium carbonate.

TABLE 17. EUROPEAN RED MITE POPULATION STUDIES, 1942

(Counts by H. A. Jaynes, U.S.D.A.)

Total mites and eggs per 100 leaves

Treatment	May 27	June 10	June 24	July 8	July 21	Aug. 4	Aug. 18	Sept. 1	Sept. 16	Totals
Sulfur-glue-lead arsenate (four sprays)	233	464	3,656	9,249	3,496	347	87	137	74	17,743
Sulfur-lead arsenate (four sprays)	309	375	2,711	3,860	1,549	381	48	53	78	9,364
Lead arsenate-talc-lime (four sprays) ..	52	70	962	1,731	1,755	98	13	9	3	4,693
Lime-sulfur-lead arsenate-manganese borate (four sprays)	218	511	2,775	6,883	4,743	134	41	77	92	15,474

sulfur and lead arsenate, and with aluminum aceto-formate, benzoic acid, sulfur and lead arsenate. No oil was used in any of these latter tests. Results are set forth in Table 18. Russeting was worst on the fruit sprayed with silica solution, lime, sulfur and lead arsenate, but insect control was fairly good in all.

TABLE 18. CONTROL OF FRUIT INSECTS ON BALDWINS AND HURLBUTS WITH SPECIAL SPRAYS AND STICKERS

Variety, Baldwin

Material and dilution per 100 gallons		Tree	Per cent good (exc. aphis)
Lime	3 pounds	L 6	94.75
Talc	3 pounds		
Lead arsenate	3 pounds	M 6	79.16
Sulfur	3 pounds		
Nalcoag (Silica Solution)	2-3 quarts	L 7	83.76
Lime	3 pounds		
Sulfur	3 pounds	M 8	89.24
Lead arsenate	3 pounds		
Lead arsenate	3 pounds	L 8	92.92
Benzoic acid	2 ounces		
Manganese borate	4 ounces		
Aluminum aceto-formate	1 pint	M 6	95.65
Sulfur	3 pounds		

Further experiments and observations on manganese borate as a safening ingredient in sulfur spray mixtures continue to be encouraging. The formula used this year was lime sulfur 1 to 1¼ gallons, soybean flour ½ pound, and manganese borate 3 ounces in 100 gallons.

Apple Maggot

PHILIP GARMAN

Five applications of .5 per cent rotenone dust in the Townsend orchard this year produced a fairly clean crop of fruit, although there was no lead arsenate applied after the calyx spray of May 16 (Table 19). It has been

TABLE 19. RESULTS OF APPLE MAGGOT CONTROL PROGRAM UTILIZING .5 PER CENT ROTENONE DUSTS AS THE KILLING AGENT

Tree	Variety	Per cent injured by maggot 1939	1940	1941	1942
B 2	Cortland	94.0	86.6	40.0	41.6
B 5	Cortland	97.0	61.0	31.0	12.0
B 9	Cortland	97.0	70.0	26.5	12.0
B 13	Cortland	99.0	70.0	28.8	12.0
B 17	Cortland	99.0	74.0	26.6	16.0
L (row)	Staymen Winesap		99.5[1]	8.8	3.2
Nearby farm untreated	McIntosh		—	97.8	—

[1] Not dusted for maggot in 1940.

observed during the course of the treatments in this orchard since 1939 that leafhoppers are not developing, possibly because of the killing action of rotenone on the adults. Only .5 per cent rotenone has been used throughout the experiment, but the carriers have been different in different years. Trees around the margins, within a short distance of unsprayed infested apples, did not bear commercially clean maggot-free fruit in 1942, although the infestation even here was much less than several years ago when the experiment was started.

Only a few chemicals were tested in the laboratory during the year. A new sample of phthalonitrile showed much poorer results than the one tested in 1941, and the cause is still unexplained. Tetramethyl thiuram monosulfide showed definite killing action on the flies when used as a pure chemical in dust form.

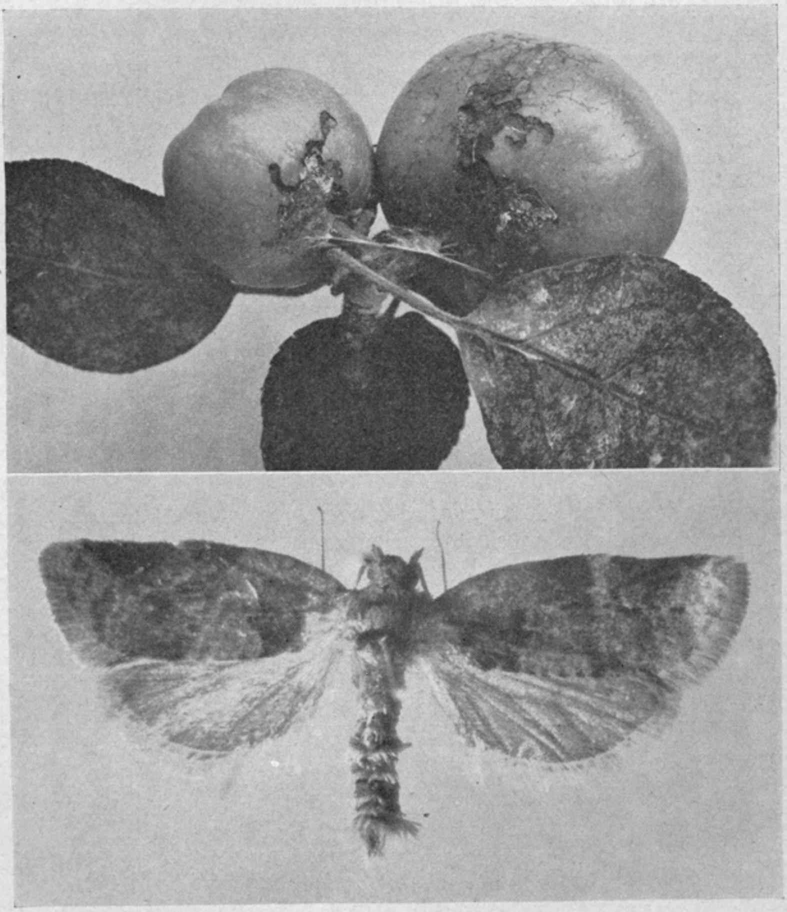

FIGURE 1. The red-banded leaf roller. Upper, typical feeding scars of the first generation larvae; lower, adult moth, greatly enlarged.

LIFE HISTORY STUDIES ON THE RED-BANDED LEAF ROLLER IN CONNECTICUT

J. F. Townsend

The red-banded leaf roller, *Argyrotaenia velutinana* Walk., has been familiar to Connecticut apple growers for many years, particularly near harvest time when the slender, active green caterpillars have been found associated with the shallow feeding areas on the fruit (Figure 1). It has been popularly called "side worm" because of the prominent appearance of the injury on the cheeks of an apple.

This is considered a native insect and has been recovered from a wide range of food plants, including fruit trees, small fruits, ornamentals, truck crops and weeds (2).

It was reported in 1918 as injuring apple in Pennsylvania (3), and again in 1920, as injuring 30 per cent of the fruit in some orchards (4) in that State. In Connecticut in 1920, it was recognized as responsible for a good deal of the late injury to apples in an experiment conducted by this Station (1), and in 1922 and 1925 was the subject of certain control experiments carried out by Walden (7).

Since 1920 the amount of injury has varied, several years sometimes elapsing between reports of substantial economic damage. These fluctuations are probably due to natural causes, although they may be favored by changes in control practice, such as the discontinuance of spraying the under side of foliage from the ground. In the late 1930's severe damage was reported in New York State. In parts of Massachusetts in 1938, 20 to 50 per cent of the apples were damaged on some trees (8). In Connecticut in 1937, 9 per cent of the apples in one orchard showed injury at harvest. In 1939, 20 to 25 per cent of the apples were found damaged in an orchard block of very large trees where thorough spray coverage was difficult. The injuriousness was much reduced in all three states in 1941 and 1942, probably from natural causes, although more effective spraying may have played a part.

Appearance of the Insect

The various stages of the insect have been illustrated by Chittenden (2).

The adult moths (Figure 1) are mottled brown in color. The female is more prominently marked than the male, with a dark, reddish-brown band that runs obliquely across the fore wing, in sharp contrast to an anterior area of light color. As viewed from above, with the wings folded, the bands form a wide, open letter "V." There are posterior bands less regular and well defined. The hind wings have a brownish tinge and wide white borders. The wingspread varies from 13 to 19 millimeters.

The eggs are deposited in irregular, flat masses (Figure 2), having the appearance of overlapping scales, which are found chiefly on the smooth bark of the trunk, branches or twigs, or on the upper surface of leaves. Some of the masses are nearly circular, with a diameter of an eighth of

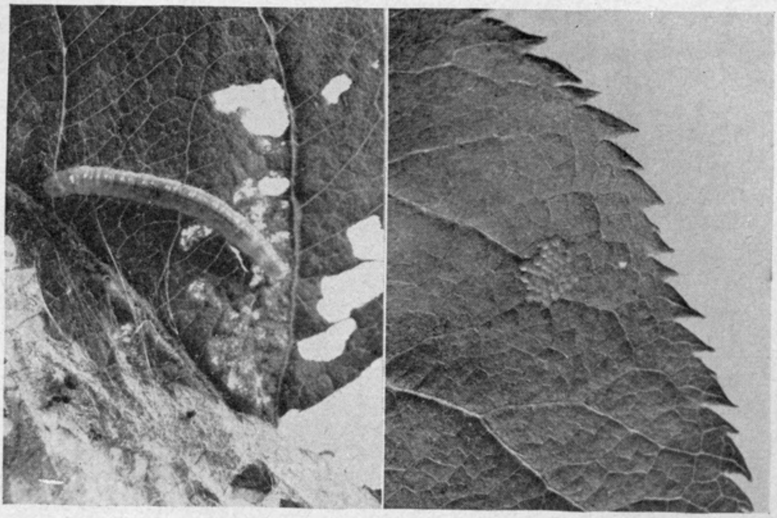

FIGURE 2. The red-banded leaf roller. Left, larva; right, egg mass. Both greatly enlarged.

an inch, but more are oval or extended, in some cases being as long as three-eighths of an inch. The newly deposited egg masses appear pale grayish green, but with the development of the embryos they assume a warm yellow tone.

The young larvae (Figure 2) are of a light yellow color which after a week or so turns to a yellowish green. The mature larvae vary in color from a light to a dull grass green. As viewed from above, some of them have the appearance of an inconspicuous striping. The intermediate stages vary between these two in appearance. The head of the red-banded leaf roller larva is not conspicuously different from the body in color, although tending toward a light brown. This serves as a ready means of distinguishing this caterpillar from the fruit tree leaf roller (*Cacoecia argyrospila* Walker), which has a shiny black head and thoracic shield. The green fruit worms (*Graptolitha* (*Xylina*) *antennata*) may be readily distinguished by their rounder and thicker bodies with the narrow white longitudinal stripes.

The pupae are 8 to 10 millimeters in length and of a dull brown color. They are often found in folded leaves on the tree in summer, and in winter in the fallen leaves where they hibernate.

Habits

The newly hatched larvae spin small patches of webbing under which they feed. On leaves the web is commonly found on the under side, in a narrow strip along the midrib or one of the prominent veins. The webs may be enlarged as the larvae continue feeding and growing, but are often left vacant. The partly grown caterpillars are most frequently found under a web in a protected spot (Figure 3), such as where two apples, or an apple and a leaf, are in contact. During thinning operations several

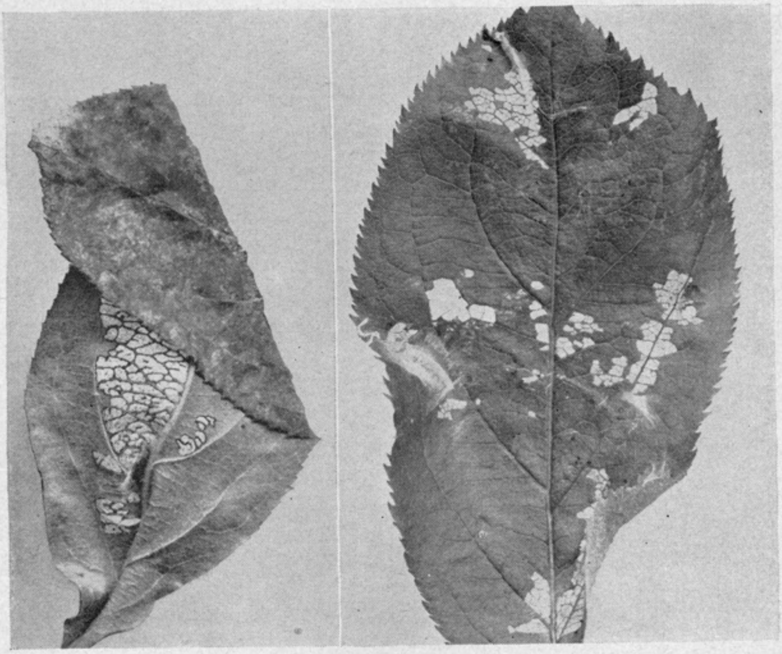

FIGURE 3. The red-banded leaf roller. Left, injury caused by larvae on the under side of an apple leaf which was sprayed on the upper surface only; right, typical feeding scars and web of young larva on apple leaf.

apples of a cluster may be found webbed together and with feeding scars somewhat deeper than those formed later in the season. Leaf feeding is chiefly on the lower surface in irregularly shaped areas which later show up sharply when the foliage is viewed against the light (Figure 3). The habit of feeding on the lower leaf surface often permits the insect to complete its development in spite of spray deposits on the upper surface.

Feeding by the caterpillars often continues during harvest, sometimes even after the apples have been placed in storage. Late feeding is particularly injurious. Because the wounds lack the opportunity for healing, rot frequently follows.

Life History Studies

With a view to a more effective use of control measures, an investigation was started in the fall of 1939 to determine the broad phases of the life history under Connecticut conditions. The study was made chiefly at the Mount Carmel insectary with stock from an infested orchard. This was checked by occasional observations in the orchard itself.

Insectary Methods and Observations

The life history in the insectary was studied with stock from fallen leaves collected in an infested orchard. The rearing technique was planned with a view to handling as large an amount of material as possible and doing the bulk of the work at irregular intervals of two to five days, as permitted by other duties. This method obviously limited the precision of certain observations, such as the time of pupation. The necessary daily routine was reduced to a minimum. The larvae were disturbed as little as possible to discourage their spinning webs in new locations.

Moths from the overwintering pupae were given a supply of moisture and food (a honey and yeast mixture) and placed for egg laying in cages with smooth twigs and, later, with apple foliage. Only fair results were obtained in egg production, partly because the cages were on some days too shaded and too cool for moth activity. The egg masses were kept in a container with fresh apple foliage for the new larvae as they emerged.

The foliage with larvae was transferred for their further development to battery jars or jelly tumblers in the insectary, or to cages of transparent material placed over growing twigs in the lower branches of a nearby apple tree. In the battery jars the foliage consisted of terminal shoots about 7 inches long with the stems set in water bottles. Ten to 20 leaves were stacked side by side in the jelly tumblers which had tight covers. Fresh foliage was supplied in the insectary as needed, and the tree cages were shifted to new twigs at about 10-day intervals. It was found necessary to transfer the larvae by hand because of their tendency to remain in the old foliage even to the point of appearing poorly fed and off-color.

Pupae, as found in the course of changing the food supply, were transferred to vials for emergence of the moths.

Orchard Life History Methods and Observations

Occasional examinations were made in an infested orchard over a three-year period. Conditions were only partially satisfactory for the purpose. The infestation proved to be declining in general, and most of it was scattered at odd points over an area of about 80 acres of orchard. The area was largely made up of old Baldwin trees, many of them slow growing and the foliage at times showing injury from the feeding of European red mites. The infestation seemed to persist chiefly on trees with clusters of small apples in a heavy set of fruit, and on some Gravenstein and Greening trees with more succulent green foliage. Some large trees of McIntosh and other varieties, adjoining the infested area on the west, showed very little evidence of feeding, and a group of old Gravenstein trees, in the same orchard but about a quarter of a mile to the west, showed no signs of infestation. In the matter of decline or freedom from infestation it was difficult to separate the effect of sprays from those of varietal preference, condition of foliage, habits of spread and other natural factors.

In the spring of 1940 the section of the orchard chosen for particular study was a block of large old Baldwins where the infestation had been very heavy the fall before and the fallen leaves had proved heavily infested. No moths were seen in the spring and only a relatively small number of egg masses were found. Egg deposition may have been discouraged by the roughness of the bark on the lower branches of these old trees, where most of the examinations were made. The resulting infestation of larvae was only moderate and after a few weeks disappeared almost completely. The decline may have been influenced by the poor condition of the foliage due to red mite feeding, and by an unusually thorough spray treatment.

A more active infestation was found on a small block of Gravenstein trees in good growing condition, where many of the subsequent orchard examinations were made. The spring egg masses were readily found here in 1941 and 1942 for observations on the hatching period. By early summer in 1942 the infestation in this block had declined to low levels.

In the studies in general, comparatively few moths or pupae were found and only a very few summer egg masses.

The presence of newly hatched larvae was revealed by the small patches of webbing on the under side of the leaf. From the size of the larvae found in a series of observations, the extent of the hatching period could be estimated.

Natural Enemies

Trichogramma pretiosa was reared from eggs collected in the orchard in the spring of 1941. About 5½ per cent of the egg masses observed in the orchard at the time showed parasitism. Indications pointed to a small amount of larval parasitism in the orchard in 1941 but definite evidence was lacking. Lists of the known parasites of the red-banded leaf roller have been published (2, 6).

Results of the Life History Studies

The records of the insectary investigations are partially illustrated in Figure 4. While neither the insectary nor the orchard study is complete in itself, it is believed that the combined information gives a reliable picture for Connecticut conditions. The length of the individual stages is also in reasonable agreement with those reported from investigations in Pennsylvania (4) although the number of generations is not the same.

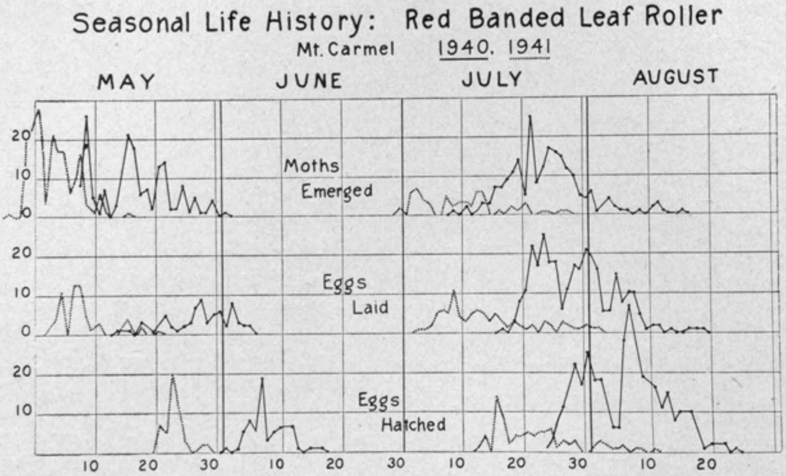

FIGURE 4. The red-banded leaf roller. Chart of life cycle.

Moths from overwintering pupae began to emerge at the insectary in early May in 1940 and in late April in 1941. Eggs were deposited beginning May 13 in 1940 and April 30 in 1941. The incubation period for individual egg masses varied in length in 1940 from nine to 18 days, average 11.8, and in 1941 from 11 to 17 days, average 15.3 days.

The first hatching of eggs occurred in the insectary in 1940 on June 1, and in 1941 on May 21. In the infested orchard, located in the town of Wallingford, the first hatching of eggs noted in 1940 was on May 27. In 1941, with 165 marked egg masses, hatching was observed from May 11 to May 23, the calyx spray being applied on May 13. In 1942, with 39 marked egg masses, hatching was observed from May 11 to May 21, the calyx spray being applied about May 14.

The total period in which first generation larvae were present in the insectary was from June 1 to about August 5 in 1940, and from May 21 to about July 15 in 1941. The time spent in the larval and pupal stages taken together in 1940 was 37 to 55 days, average 45.7 days, in the case of 133 individuals in the insectary; in cages on a nearby tree 42 to 58 days, average 48.5 days, with 64 individuals. In 1941 in the insectary it was 46 to 64 days, average 53.5 days, with 14 individuals; in tree cages in 1941, 51 to 59 days, average 54.4 days, with 8 individuals. From a group of first-generation larvae collected in the orchard in 1941 pupation was observed from June 20 to July 19.

The emergence of moths from the first-generation larvae at the insectary began on July 9 in 1940 and on July 3 in 1941. From first-generation larvae collected in the orchard the emergence of moths extended from June 30 to July 28, with a total of 60 moths.

Second-generation eggs were deposited in the insectary in 1940 beginning on July 17, and in 1941 on July 3. The incubation period for individual egg masses varied in 1940 from 7 to 13 days, average 7.7 days; in 1941 from 7 to 10 days, average 8.3 days.

The hatching of second-generation eggs began at the insectary in 1940 on July 24, and in 1941 on July 13. In the orchard recently hatched larvae were observed in 1940 from August 6 to 19; in 1941, from July 28 to August 18; and in 1942, from July 31 to August 15.

The fall feeding of larvae continued in the insectary in 1940 until early November. Pupation was observed from the middle of October to the middle of November.

Summary

The investigation has shown two annual broods of larvae in Connecticut, the first from eggs hatching near the time of petal fall and extending to mid-July or early August, and the second from eggs hatching in late July or early August and extending through harvest. The importance of a thorough coverage of the foliage and fruit with insecticides early in the season before the larvae have had the opportunity to establish themselves under a web in a protected location is indicated.

The decline after several years of unusual abundance can be largely attributed to natural causes.

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THE EUROPEAN CORN BORER IN CONNECTICUT

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A study of the seasonal development of the European corn borer, *Pyrausta nubilalis* (Hbn.), was begun by the federal Bureau of Entomology and Plant Quarantine at Hartford, Conn., in the summer of 1934 and continued at New Haven in each of the following summers through 1940. The purpose of this study was the accumulation of data on the reactions of the insect to the changes in its environment produced by the operation of weather and other factors. Emphasis was placed on egg deposition and subsequent survival of borer larvae and their various interrelations. The seasonal data as obtained currently have been of value in several phases of European corn borer research. Special surveys were made in Connecticut to learn the extent of corn borer infestation in early market sweet corn and in white potatoes. Since 1927 surveys had been conducted each fall to determine the annual relative abundance of the insect in corn over parts or all of the State.

Status of the Borer in Connecticut

Early Records

The European corn borer was discovered for the first time in Connecticut in 1923 when two coastal townships in New London County were found infested. The insect was noted in New Haven and Fairfield counties in 1924 and in Middlesex County in 1925, and first records were obtained from the remaining four counties of the State in 1928 and 1929. Borer populations of economic importance, however, were not apparent in Connecticut until 1933, when averages of 3.9, 1.5 and 1.1 larvae per plant occurred in corn in Hartford, Middlesex and New Haven counties, respectively.

[1] The writer is glad to express appreciation to W. A. Baker, in charge of European corn borer research, for his interest and help during these investigations, and to the Bureau employees engaged on the project, for their splendid cooperation and careful work. All credit for the procuring of the detailed field data in Connecticut, on which this entire discussion is based, is due the following men: E. D. Burgess, for a study of the seasonal development of the corn borer near Hartford and the conduct of sweet corn surveys in Hartford and New Haven counties in 1934; N. J. Nerney, for his conduct of seasonal-development studies of the insect and all surveys of its abundance in New Haven County from 1935 to 1940, inclusive, and for assistance during the fall surveys of other counties in the State; and C. A. Clark, S. W. Carter, E. L. Gilbert and H. L. Chada, for assisting in various surveys of corn borer populations in Connecticut at different times during the period of the investigations. C. H. Batchelder, in charge of the corn borer substation at New Haven, kindly furnished needed facilities for the field men. Worthwhile suggestions relating to the manuscript were contributed by R. B. Friend, State Entomologist of Connecticut, and his staff, and special appreciation is due Dr. Friend for making possible the publication of the paper in his present report.

General Fall Abundance in Field Corn

Beginning in 1932, fall populations of the insect in field corn[1] in New Haven and Hartford counties, where annual fall survey records have since been continuous, followed a trend of increase until 1937. They remained at about the same level in 1938 as in 1937, and then tended toward decreases in 1939, 1940, 1941 and 1942. More limited data for other counties indicated similar trends over much of the State. During this period severe damage to both sweet and field corn occurred at times in different parts of Connecticut, particularly in Hartford and New Haven counties, where fall populations of the corn borer averaged as high as 11 and eight larvae per plant, respectively, in both 1937 and 1938. The general trends of corn borer abundance from 1932 to 1942 in Hartford and New Haven counties combined are illustrated in Figure 5, and the fall populations in individual counties surveyed in Connecticut during the period 1927-42 are given in Table 20. The fall survey data were obtained by counts in September of each year in a given number of cornfields taken at random in each county. The following numbers of fields per county were surveyed in the different years: 25 to 30 in 1927-33, 20 in 1934-38, and 10 in 1939-42.

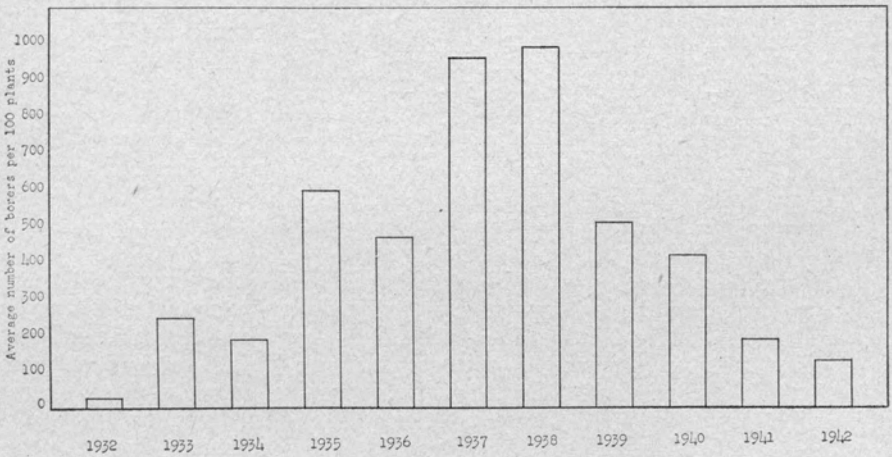

FIGURE 5. Fall abundance of European corn borer in corn, Hartford and New Haven counties, 1932-42.

During the period 1927-38 the sampling procedure in each field consisted of a count of 100 plants, 25 in the center of each quarter of the field, for infestation. Ten infested plants, or five in light infestations, out of those found infested were dissected to determine the number of borers per infested plant. In the period 1939-42 only 25 plants near the middle of one side of the field were examined for infestation, and two infested plants

[1] Sweet or ensilage corn rarely was found in the random sampling of fields during the fall surveys.

dissected out of this number. The resultant data in all years were presented on the basis of number of borers per 100 plants.

Infestation of Early and Late Sweet Corn

Environmental conditions in southern and central Connecticut have proved especially favorable to the European corn borer. The first generation of the insect has extensively infested early market sweet corn. As a result, heavy damage to this crop from high populations of the pest has

Table 20. Fall Abundance of the European Corn Borer in Connecticut, by Counties, 1927-42

Counts of Borers Per 100 Plants

Year	Fairfield	Hartford	Litchfield	Middlesex	New Haven	New London	Tolland	Windham
1927	—	—	—	—	—	0	—	—
1928	—	—	—	—	—	6.0	—	0.1
1929	—	—	—	5.0	0.2	25.9	0.8	11.5
1930	—	—	—	3.0	0.3	9.1	0.4	9.4
1931	—	—	—	—	—	—	—	—
1932	—	50.7	—	31.5	2.4	76.7	—	—
1933	—	387.4	—	153.6	107.9	49.7	—	—
1934	—	61.3	—	318.2	325.0	135.8	—	—
1935	—	721.4	—	415.8	469.2	44.7	—	—
1936	—	538.9	—	119.0	391.7	—	—	—
1937	—	1,077.2	—	—	845.5	—	—	—
1938	—	1,130.3	—	—	842.5	—	—	—
1939	321.4	520.4	300.2	425.4	503.2	807.2	366.8	523.0
1940	539.6	448.4	213.8	472.2	393.4	256.8	277.6	185.6
1941	121.8	235.8	9.6	63.6	143.4	28.2	41.6	11.0
1942	91.8	106.4	9.6	105.6	145.4	81.2	22.6	12.8

been common for a number of years. Table 21 presents the data on infestation in market sweet corn by the first generation of the borer in the vicinity of Hartford in 1934 and 1935 and near New Haven from 1934 to 1942, inclusive, and by the second generation at New Haven from 1935 to 1938, inclusive. The special-survey data were obtained by the examination of 25 of the earliest infested fields in a county each year, with one exception in 1934 when only 21 fields were surveyed at New Haven. In each field 100 plants were examined for infestation and 10 infested plants dissected to determine the number of borers per infested plant. The data of fields for egg study are based on the examination and dissection annually of the 20 plants in each of the 10 fields kept under regular observation for egg deposition. One exception occurred at New Haven in 1938, when only eight fields were utilized in the study of eggs of the second generation. The fields which were observed regularly each year in a study of the egg deposition of the moth are discussed later. Data on infestation of these fields are shown in Table 21.

To study further the relation between egg deposition and larval survival, all corn plants under observation during the years 1934 to 1940, inclusive, were placed in groups on the basis of the number of eggs deposited on each. It was found that the annual groupings of the data, as well as the combined figures, revealed more clearly the close association between eggs and larvae. The data for the 11 generations combined are given in Table 28, and the relationship, as it applied to these figures, is expressed in Figure 6 as a straight line. This line, if projected toward its very low limits, would curve rather sharply toward zero.

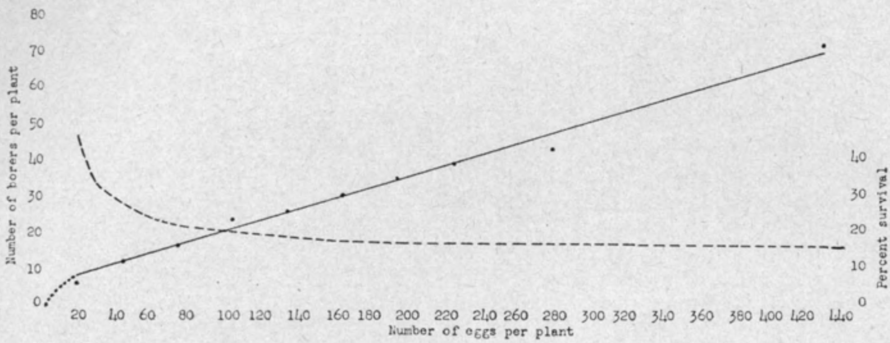

FIGURE 6. Relationship of average number of eggs of the European corn borer with average number of larvae surviving per corn plant, shown by a solid line; and the relationship of the average number of eggs per plant with the per cent survival, derived from the same data, shown by a broken line. Based on the combined data for 11 generations of the insect in Connecticut, 1934-40.

The maximum larval survival on the 11 generations combined amounted to 37.7 per cent and occurred on corn plants that received an average of 17.5 eggs per plant and were infested with 6.6 borers per plant. With additional eggs per plant, survival decreased fairly rapidly at first but tended to become constant at approximately 17 per cent, when the population in general exceeded 200 eggs per plant. Data for determining survival figures for high egg and larval populations were less extensive than were those for the lighter infestations. These findings agree with those of Patch and Peirce (6) in indicating that although increased borer populations result from increased numbers of eggs, the percentage of survival of the borer decreased as the borer density per plant increased. These writers also found the same relationship between number of eggs per plant and per cent larval survival as did the present writer. It is probable that predators play a much more important part in the degree of survival than is usually realized, and it is likely that the proportion of eggs and young larvae of the corn borer destroyed by predaceous Arthropoda increases with concentrations of their victims.

TABLE 21. ABUNDANCE OF THE EUROPEAN CORN BORER IN SWEET CORN IN CONNECTICUT, 1934-42

Locality	Year	Special-survey fields: Per cent plants infested	Special-survey fields: Average borers per 100 plants	Egg-study fields: Per cent plants infested	Egg-study fields: Average borers per 100 plants
		First generation			
Hartford	1934	83.3	446	69.5	299
	1935	58.4	225	—	—
New Haven	1934	84.3	521	—	—
	1935	87.8	675	86.0	679
	1936	—	—	78.5	785
	1937	—	—	76.5	689
	1938	97.4	878	90.5	815
	1939	100.0	1,980	99.0	2,356
	1940	82.9	493	89.5	850
	1941	49.8	109	—	—
	1942	75.6	791	—	—
		Second generation			
New Haven	1935	—	—	100.0	1,390
	1936	—	—	93.5	991
	1937	—	—	99.5	3,114
	1938	—	—	96.3	1,887

In the years 1934 to 1938, and in 1940, populations of the insect (first generation) in early sweet corn in New Haven County averaged between 493 and 878 borers per 100 plants. In 1939, a maximum of 1,980 larvae per 100 plants was found in the special-survey fields in that county. A very decided decrease in numbers of the insect in the early crop of sweet corn in Connecticut occurred in 1941, when only 109 borers per 100 plants were found at New Haven. This was followed, however, by a return to damaging populations in 1942, with an average of 791 borers per 100 plants. According to these data and those procured in the egg studies in later fields of sweet corn under observation for the second generation of the corn borer, the insect was more abundant in late than in early sweet corn near New Haven in each of the years 1935 to 1938, inclusive. The second-generation populations in this period ranged from 991 borers per 100 plants in 1936 to as high as 3,114 in 1937. At the time of the heaviest infestation practically all sweet corn plants in the fields were infested, damage to the ears for market was severe, and the crop in some fields was a complete loss.

It can generally be expected that high fall populations of the second generation, both in late sweet corn and in corn as a whole, will follow heavy infestation of the first-generation borers in early corn. Exceptions to this have occurred, however. In 1939 the general fall population (second generation) of the insect in New Haven County showed a significant decrease from the fall population of 1938, in spite of the heaviest infestation in early sweet corn recorded for the borer in Connecticut. Abundance of the insect in late sweet corn only was not determined in 1939, but it is probable that the second generation in this crop followed the trend of decrease found in fall populations of the insect in field corn that year.

In the years 1935-38, for which comparisons are available for New Haven County, the second-generation populations in late sweet corn were always several times as high as those found in the random surveys conducted chiefly in field corn in the fall of the same years. These differences may be accounted for in part by the greater acreages of corn involved in the fall surveys, and possibly also by the tendency for late sweet corn to be planted on truck farms in the proximity of early sweet corn grown the same year and heavily infested by the borer.

Seasonal History

Generally speaking, the European corn borer has two generations annually in Connecticut, although it is possible that a very small proportion of the population in certain parts of the State may have only a single generation a year. Some indication was procured in 1937, when pupae were found in the field at New Haven as late as September 8, that a partial third generation might develop in this section in years particularly favorable for accelerated development of the insect. Such a possibility is supported by the fact that Arbuthnot (1) found the multiple-generation strain of the borer in New Haven capable, under imposed developmental conditions in the laboratory, of producing one generation after another without the intervention of a diapause. The multiple-generation corn borer occurring in southern Connecticut appears to be well adapted to its environment. Normal winter mortality is usually under five, and seldom over 10, per cent.

After overwintering in the larval stage within old cornstalks, weeds or other debris, the corn borer in the vicinity of New Haven usually begins to pupate near the end of April. Emergence of the earliest moths follows about the middle of May. Oviposition of the first generation becomes noticeable in the field during the last few days of the month and continues throughout June and sometimes into early July. Larvae hatching from these eggs mature in July and pupate, producing moths which deposit eggs of a second generation in late July, August and occasionally into early September. The full-grown borers of this generation hibernate in the field. Prevailing seasonal conditions influence somewhat the time of occurrence in the field of the various stages of the insect.

Egg Studies

Procedure

Extensive observations on the oviposition of the corn borer under natural field conditions in Connecticut were made as follows: In 1934, on the first and second generations of the insect at Hartford; in 1935-38, on both generations at New Haven, and in 1939-40, on only the first generation infestation in early sweet corn recorded for the borer in Connecticut. Abundance of the insect in late sweet corn only was not determined in 1939, but it is probable that the second generation in this crop followed the trend of decrease found in fall populations of the insect in field corn that year.

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Egg Studies

Procedure

Extensive observations on the oviposition of the corn borer under natural field conditions in Connecticut were made as follows: In 1934, on the first and second generations of the insect at Hartford; in 1935-38, on both generations at New Haven, and in 1939-40, on only the first generation at New Haven. The procedure each year was practically the same. The studies for each generation were conducted in 10 fields of sweet corn distributed over an area of approximately 100 square miles. The one exception occurred in 1938, when a field of ensilage corn was included in the group of second-generation fields. The fields were selected on the basis of their apparent attractiveness for the ovipositing corn borer moths. In the case of the first generation they were also generally the earliest in the locality. In each field 20 normal corn plants, spaced at more or less regular intervals across the width of the field, were tagged and given numbers to designate them in the records throughout the period of observation. In 1934, 1935 and 1936—years in which the fate of the eggs was determined—each egg mass on these plants when found was assigned a number and its location on the corn plant was marked with black India ink to facilitate identification in subsequent examinations. The number of eggs in each mass was always counted. Observations were made daily during essentially each entire period of oviposition in the years 1934, 1935 and 1936, and every third day in the years 1937 to 1940, inclusive.

The amount of corn involved in the 10 fields under observation varied with the year and generation. The total area in the first-generation studies each year averaged about 23 acres, and in the second-generation studies, about 16 acres. Approximately 78 per cent of the fields subject to infestation by the first generation of the borer were planted from April 15 to 25, inclusive, the remainder being planted earlier or later in that month or early in May. The planting dates of fields affected by the second generation of the insect extended over almost a month, from near the middle of June to the middle of July, about 60 per cent of the fields being planted from June 20 to July 1, inclusive.

Occurrence and Amount of Oviposition

Data on the seasonal occurrence and amount of oviposition of the first and second generations of the corn borer in various years from 1934 to 1940 in southern Connecticut are given in Tables 22 and 23. Graphs showing the average occurrence of egg deposition at New Haven from 1935 to 1940 are presented in Figure 7.

Most of the eggs of the first-generation moths at New Haven were deposited in the period May 29 to July 12, although it is known that a few were laid before and after these dates in certain years. The peak of oviposition generally occurred near the middle of June. During the six-year period 1935-40 at New Haven an average of 67.8 per cent of all the eggs were deposited from June 8 to 22, inclusive. Oviposition of the second generation, beginning near the end of July, continued throughout August and sometimes into the first few days of September. The average peak of oviposition of the second generation at New Haven during the period 1935-38 occurred about the second week in August, and 89 per cent of the eggs were deposited from August 2 to 21.

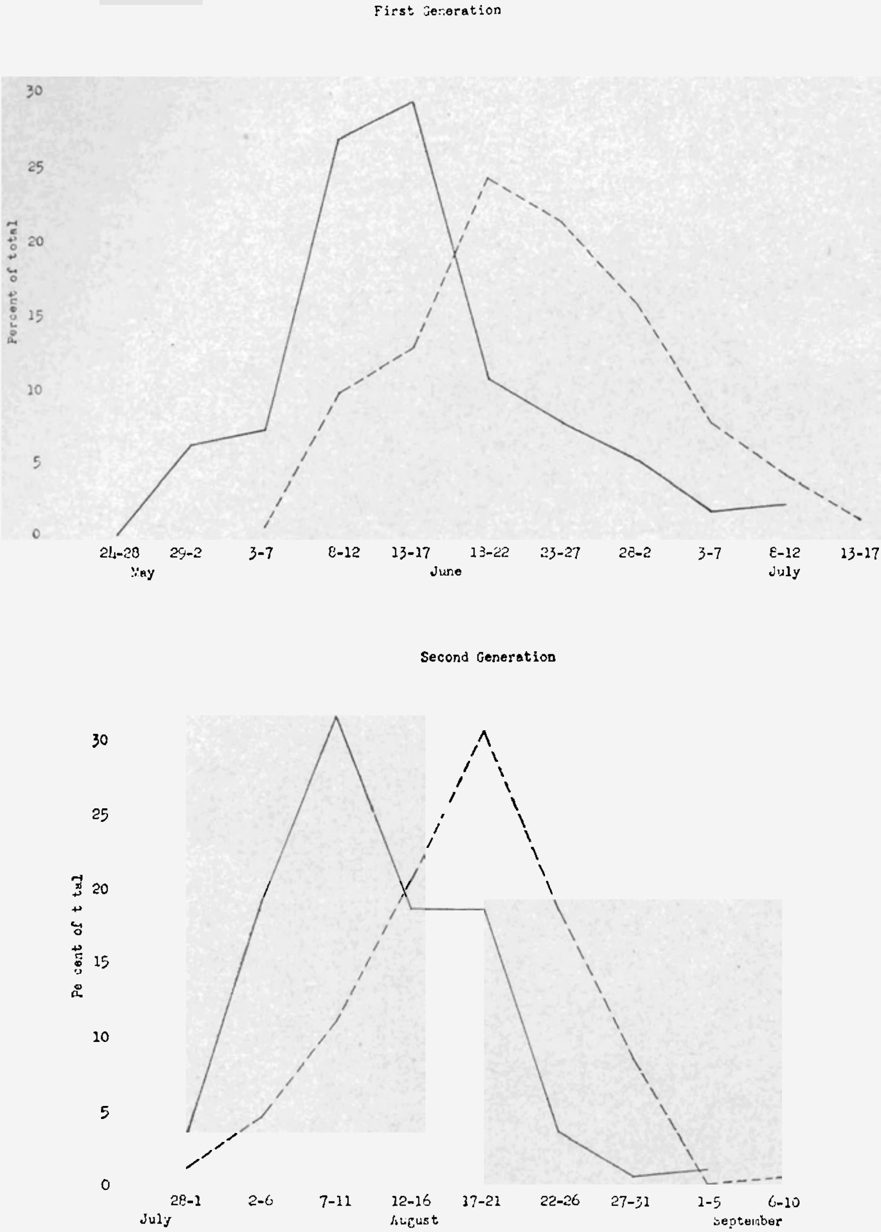

FIGURE 7. Average deposition of eggs of the first generation of the European corn borer, 1935-40, and of the second generation, 1935-38, at New Haven; and hatching of eggs of both generations in 1934 at Hartford and in 1935-36 at New Haven. Oviposition is indicated by a solid line and hatching by a broken line.

TABLE 22. OVIPOSITION OF THE FIRST GENERATION OF THE EUROPEAN CORN BORER IN EARLY SWEET CORN AT HARTFORD IN 1934, AND AT NEW HAVEN IN 1935-40[1]
Counts of Egg Masses Per 100 Plants

Five-day period	Hartford 1934	New Haven 1935	1936	1937	1938	1939	1940	Average number	Per cent of total
May 24–28	—	—	—	—	1	—	—	1.0	0.5
May 29–June 2	—	—	2	5	8	40	—	13.8	6.5
June 3–7	9	5	25	35	6	15	11	16.2	7.6
June 8–12	17	15	61	34	16	202	16	57.3	26.9
June 13–17	17	65	69	47	50	82	67	63.3	29.7
June 18–22	23	28	16	15	17	37	30	23.8	11.2
June 23–27	19	25	2	9	30	30	8	17.3	8.1
June 28–July 2	13	20	3	6	21	—	6	11.2	5.3
July 3–7	2	5	—	—	—	—	3	4.0	1.9
July 8–12	—	2	—	—	—	—	8	5.0	2.3
Total	100	165	178	151	149	406	149	212.9	

[1] Based on counts taken on 200 plants in selected fields in each of the years considered.

TABLE 23. OVIPOSITION OF THE SECOND GENERATION OF THE EUROPEAN CORN BORER IN CORN AT HARTFORD, CONN., 1934, AND AT NEW HAVEN, CONN., 1935-38[1]
Counts of Egg Masses Per 100 Plants

Five-day period	Hartford 1934	New Haven 1935	1936	1937	1938	Average number	Per cent of total
July 28–August 1	4	3	11	—	42	18.7	3.9
August 2–6	98	49	43	138	141	92.8	19.3
August 7–11	56	37	51	358	166	153.0	31.9
August 12–16	71	88	49	142	83	90.5	18.9
August 17–21	22	164	50	64	84	90.5	18.9
August 22–26	6	33	6	9	39	21.8	4.5
August 27–31	6	5	—	5	6	5.3	1.1
September 1–5	—	—	—	—	7	7.0	1.5
Total	263	379	210	716	568	479.6	

[1] See footnote of Table 22.

Almost three (2.9) times as many masses per 100 plants were deposited by moths of the second as by those of the first generation in Connecticut in the five comparable years of study, 1934-38. As mentioned later, the egg masses of the second generation contained more eggs than those of the first generation.

Location and Size of Egg Masses

Records were taken on 2,171 egg masses of the corn borer laid on corn plants at Hartford in 1934, and at New Haven in 1935 and 1936. Of these masses, 93.8 per cent were located on the lower surfaces of the leaves, 4.2 per cent were on the upper surfaces of the leaves, 1.5 per cent were on the stalks and 0.5 per cent were on the ears, including the silks. The distribution of the eggs on the plants in the first and second generation was approximately the same. Around 75 per cent of the 2,128 egg masses deposited on the corn leaves were found on the lower five leaves of the plants, the remaining 25 per cent being laid on the next higher seven or eight leaves.

The average numbers of eggs per mass on corn in the vicinity of Hartford in 1934 and at New Haven in various years from 1935 through 1940 are shown in Table 24. In the seven-year period mentioned, the average mass of the first generation contained 16.2 eggs and in the five-year period, 1934-38, that of the second generation, 18.7 eggs. There was a tendency for moths of the second generation to deposit more eggs at each oviposition than did those of the first generation, although it is not known that the total egg complement of the female was greater in one case than in the other. It is possible that the female moths of the second generation live under more favorable temperature conditions than those of the first generation and less often encounter temperatures low enough to interfere seriously with their normal activity and oviposition.

TABLE 24. SIZE OF EGG MASSES OF THE EUROPEAN CORN BORER NEAR HARTFORD IN 1934, AND NEAR NEW HAVEN, 1935-40

Locality	Year	First generation: Masses examined	First generation: Average eggs per mass	Second generation: Masses examined	Second generation: Average eggs per mass
Hartford	1934	200	17.1	518	20.7
New Haven	1935	329	16.7	751	18.4
	1936	353	15.4	419	17.8
	1937	301	17.3	1,452	17.8
	1938	296	16.2	1,070	18.9
	1939	830	15.8	—	—
	1940	297	14.6	—	—
Average		—	16.2	—	18.7

Incubation and Hatching of Eggs

The incubation period of eggs of the first generation ranged from 6.7 days at Hartford in 1934 to 6.9 and 8.1 days at New Haven in 1935 and

1936, respectively, while that of the second-generation eggs ranged from 5.2 and 5.3 days at New Haven in 1935 and 1936, respectively, to 6.7 days at Hartford in 1934. The average period in the field was 7.3 days for the first generation and 5.6 for the second. The shortening of the incubation period of the eggs in the second, as compared with the first generation, at New Haven was perhaps due to a speeding up of embryonic development as a result of generally higher temperatures prevalent in late than in early summer. Caffrey and Worthley (4) reported the duration of the egg stage as obtained from insectary records at Arlington, Mass., during the period 1919 to 1921, inclusive, as ranging from 7 to 7.16 days for the first generation and from 6.25 to 7.84 days for the second generation.

The seasonal progress of hatching in five-day periods for 1934-36 is shown in Table 25, and the average hatch for the three years is illustrated in Figure 7. Hatching of eggs of the first generation in Connecticut began early in June and continued into the third week of July, an average of 75 per cent of the total hatch in the seasons studied taking place during the period June 13 to July 2. Second-generation eggs began to hatch in the last few days of July, and some eggs were still hatching in the field in the second week of September, 82.7 per cent of them hatching during the period August 7 to 26.

TABLE 25. HATCHING OF EGG MASSES OF EUROPEAN CORN BORER, HARTFORD, 1934, AND NEW HAVEN, 1935-36

Figures given in per cents

Five-day period	Hartford 1934	New Haven 1935	New Haven 1936	Average
First generation				
June 3–7	1.2	—	—	0.8
8–12	5.7	—	14.8	9.9
13–17	6.9	9.5	23.1	13.1
18–22	23.9	17.7	36.7	24.7
23–27	19.5	31.5	16.0	21.3
28–July 2	22.0	22.8	8.6	16.1
July 3–7	17.0	11.0	0.8	8.0
8–12	3.8	5.9	—	4.4
13–17	—	1.6	—	1.7
Second generation				
July 28–August 1	—	—	1.6	1.3
August 2–6	11.6	2.7	2.9	5.2
7–11	19.7	6.7	11.1	11.3
12–16	29.8	14.8	23.7	21.1
17–21	21.7	28.7	46.8	31.1
22–26	8.6	32.0	10.4	19.2
27–31	8.6	14.1	2.2	9.2
September 1–5	—	0.2	1.3	0.6
6–10	—	0.8	—	1.0

Fate of Eggs

During the period of incubation the eggs of the European corn borer on the corn plants are subjected to the vicissitudes of the prevailing weather and to the effects of parasitization and predation by other insects. At Hartford in 1934 and at New Haven in 1935 and 1936, daily examinations were made of all egg masses of both the first and second-generation borers found on 200 corn plants (20 plants in each of 10 fields at each place), and the fate of the eggs was determined as accurately as possible. The data obtained are given in Table 26.

An average of 74.2 per cent of all eggs under observation in the three years hatched normally, the maximum hatch being 81.5 per cent in the first generation at Hartford in 1934, and the minimum 68.9 per cent in the second generation at New Haven in 1935. A small proportion of the eggs were recorded as infertile and a few eggs dried up on the plants. About 4.5 per cent were parasitized by *Trichogramma* sp., and an average of 2.9 per cent were destroyed by predators. Winds and driving rains caused a certain small percentage of the eggs to become dislodged from the plants, and other eggs were missing from undetermined causes. In some years conditions in the field are more hazardous for eggs of the second than for those of the first generation. By the time the second-generation eggs are laid, insect parasites and predators, in particular, have had an opportunity for a seasonal increase in numbers and thus have become more important factors in egg destruction.

On the basis of these three years' data it can reasonably be expected that, in more or less average seasons, approximately three-fourths of the eggs deposited by moths in Connecticut will hatch and that the balance will be destroyed in varying proportions by the several factors constituting the resistance of the environment. It was estimated that in 1934, at Hartford, 22.4 per cent of the total mortality that occurred in the first generation of the borer took place during the hatching period while the remainder occurred in the course of larval life. In 1935, at New Haven, the proportion of total mortality occurring in the egg stage was estimated at 27.9 per cent in the first and 38.9 per cent in the second generation. In other words, less than one-third of the loss of potential borers in the plants occurred in the egg stage.

Relationship of Eggs and Surviving Larvae

During any given season or period of seasons, individual corn plants under natural field conditions receive different numbers of corn borer eggs and ultimately support larval populations of varying size. The variability in numbers of eggs per plant is the result of chance distribution of egg masses by the female moths in combination with the preference or nonpreference of the insect for certain plants, the reason for which is not yet understood. The final larval population depends not only on the number of eggs deposited but also on the proportion that escape destructive

TABLE 26. FATE OF EGGS OF EUROPEAN CORN BORER AT HARTFORD, CONN., IN 1934, AND AT NEW HAVEN, CONN., IN 1935 AND 1936

Locality	Year	Eggs: Total observed	Per cent hatched	Per cent infertile	Per cent desiccated	Per cent parasitized by Trichogramma	Per cent destroyed by predators	Per cent dislodged	Per cent missing
First generation									
Hartford	1934	3,423	81.5	0.7	0.7	0	1.5	1.8	13.8
New Haven	1935	5,512	79.0	5.5	0.7	3.9	0	6.1	4.8
	1936	5,477	71.2	3.5	4.5	9.7	1.0	4.1	6.0
Second generation									
Hartford	1934	10,412	70.0	0.4	0.3	5.1	7.2	0	17.0
New Haven	1935	13,892	68.9	7.2	9.8	4.4	3.4	1.4	4.9
	1936	7,445	74.9	4.5	5.0	4.1	4.1	3.0	4.4

TABLE 27. SURVIVAL OF THE EUROPEAN CORN BORER IN SWEET CORN AT HARTFORD, IN 1934, AND AT NEW HAVEN, 1935-40

Year and locality	First generation: Average eggs per plant	Average borers per plant	Per cent survival	Second generation: Average eggs per plant	Average borers per plant	Per cent survival
Hartford						
1934	17.1	3.0	17.5	—	—	—
New Haven						
1935	27.6	6.8	24.6	69.5	13.9	20.0
1936	27.4	7.8	28.5	37.2	10.0	26.9
1937	26.0	6.9	26.5	127.8	31.1	24.3
1938	24.0	8.2	34.2	112.4	17.6	15.7
1939	65.7	23.6	35.9	—	—	—
1940	21.7	8.5	39.2	—	—	—
Average						
(7 years)	29.9	9.3	29.5	—	—	—
(4 years)	—	—	—	86.7	18.2	21.7

forces to produce larvae and the proportion of these that survive in a more or less perilous micro-environment to establish themselves in the plant tissue.

Soon after the completion of each series of egg observations in Connecticut, the corn plants utilized in the study were dissected thoroughly and a record made of the number of corn borer larvae established in them. From the data on the eggs deposited on the selected plants and the larvae recovered therefrom, the percentage of borer survival was calculated for each year and generation. These data are presented in Table 27. It is true that borer survival is extremely variable and that in each case it would have been somewhat decreased if the data had been taken later in the season. However, the corn considered in all the years was in approximately the same general stage of development when the eggs were deposited, and the dissections of the plants for the survival data were made at relatively the same time with regard to borer and plant development. With these considerations in mind, it is believed that the survival figures for the years studied are comparable and that sufficient data were obtained in southern Connecticut to provide a good generalized average of borer survival for early and late sweet corn in that particular region for years of the type included in these studies.

Survival in Connecticut in sweet corn in the first generation for the seven years 1934 to 1940, inclusive, averaged 29.5 per cent, with a minimum of 17.5 per cent in 1934 at Hartford and a maximum of 39.2 per cent in 1940 at New Haven. In the second generation at New Haven and for the four years 1935 to 1938, inclusive, it averaged 21.7 per cent, with a minimum of 15.7 per cent in 1938 and a maximum of 26.9 per cent in 1936. Survivals in most years tend to be a little higher in the first than in the second generation, and a difference of this character was pronounced in 1938, when a survival at New Haven of 34.2 per cent in the first generation contrasted with one of 15.7 per cent in the second generation. It is probable that survival in Connecticut in the above years was lower than here indicated on some field and sweet corn which was subject to other conditions than those represented in these investigations.

The data given in Table 27, comprising the number of eggs per plant, the average number of resulting borers per plant and the per cent survival obtained from these measurements, indicated a close relationship between numbers of eggs and numbers of borers; namely, that increased numbers of borers were dependent principally upon increased numbers of eggs. For example, in the first generation at New Haven there was comparatively little variation in the numbers of eggs and the numbers of larvae surviving from them in the years 1935-38 and in 1940, whereas a very definite increase in borer population occurred in 1939 as a result of a much larger egg deposition than in the other years.

TABLE 28. ABUNDANCE OF EGGS OF THE EUROPEAN CORN BORER AS RELATED TO SURVIVING LARVAE ON SWEET CORN AT HARTFORD, CONN., IN 1934 AND AT NEW HAVEN, CONN., IN 1935-40, BASED ON THE RECORDS OF 11 GENERATIONS OF THE INSECT

Plants in group	Average eggs per plant	Average larvae per plant	Per cent survival of larvae from eggs
530	0	3.1	—
602	17.5	6.6	37.7
426	43.5	12.5	28.7
274	74.1	17.2	23.2
146	104.4	24.2	23.2
61	134.0	26.7	19.9
41	163.6	30.8	18.8
24	194.1	35.3	18.2
17	224.8	39.7	17.7
27	279.0	43.6	15.6
32	428.3	71.8	16.8

Further study of the data for the four-year period 1935-38 at New Haven showed that no eggs of the borer were found on an average of 32.5 per cent of the corn plants under observation during the time of the first generation and none was recorded on 13.3 per cent of the plants during the prevalence of the second generation. In the former case 12.1 per cent of the larval population occurred on the third of the plants that received no eggs, and in the latter, 3 per cent of the surviving larvae were on the plants without eggs. Of course, there was always the possibility that a few egg masses were missed during observation, both on plants with and on those without recorded eggs, but some of the larvae on plants without recorded eggs were undoubtedly migrants from surrounding plants. As might be expected with the increased oviposition of the second over the first generation as already discussed, less than half as many plants escaped second-generation eggs as escaped first-generation eggs, and the same kind of relationship held with regard to the proportion of the final population occurring on plants without eggs.

Infestation in White Potatoes

Jones et al. (5) have shown by experiments conducted on the Eastern Shore of Virginia that yields of white potatoes are reduced very little by the European corn borer. Nevertheless, potato plants often harbor an important number of the first-generation borers. This is true in Connecticut and, in addition, late varieties in the State are frequently infested with larvae of the second generation. Twenty-five fields of potatoes, both early and late, taken at random, were surveyed in central Connecticut in 1937 and found infested with an average of 106 borers per 100 plants. In 1938, during the period July 26 to August 2, a survey of 13 fields of the late variety Green Mountain showed an average of 356 borers of the first generation per 100 plants; at the time of a second examination, September 12-16, the same fields contained an average of 168 larvae per 100 plants, probably all the second generation of the insect.

First-generation egg counts were taken in one field of white potatoes near New Haven in 1937. In this field 23 egg masses were deposited on the 20 plants under observation from June 7 to 24. At this rate, 115 masses were laid per 100 potato plants in the field as compared with an average of 145 masses per 100 plants in 10 fields of the most attractive sweet corn observed over the same period of time. The average egg mass on the potato plants contained 13 eggs in comparison with 17.3 on the corn. Larval survival on the potato plants that season was 15.7 per cent whereas on the corn it was 26.5 per cent. This was confirmed by Beard (3).

Association of Borer Abundance with Weather

Recognizing the extreme importance of weather in its effects on the European corn borer, an effort was made to associate corn borer oviposition and abundance in Connecticut with weather conditions prevalent during the period of study. As with other attempts of this nature, only partial success was obtained.

Significant increases in the population of the borer in the fall of a given year from that of the previous fall were found in New Haven County in 1933, 1934 and 1937, and decreases in 1939 and 1941. In general the trends in abundance in New Haven County characterized other counties of the State which were surveyed in the same years (see Table 20). However, in the years of study not marked by a significant increase or decrease in borer population, numbers of the insect still were relatively high, a fact suggestive of favorable environmental conditions for the pest. Further, it should be noted that, except in 1941, the insect continued to occur in numbers sufficient to cause serious damage, regardless of changes in annual levels of abundance.

Undoubtedly the 1941 season was the most unfavorable one to which the corn borer was subjected in Connecticut up to that time. The average number of first-generation borers per 100 plants in early market sweet corn in New Haven County decreased from 493 in 1940 to 109 in 1941, and the fall population dropped from 393 borers per 100 plants in 1940 to 143 in 1941. Weather conditions were probably responsible for this reduction in borer abundance. After unusually warm, dry weather in Connecticut in the spring of 1941, particularly in April and May, a large proportion of the moths from overwintered borers emerged much earlier than normally, and many of them were exposed to cool rains early in June. Egg data were not procured at New Haven in 1941, but it can reasonably be assumed from the light oviposition known to have occurred that year in eastern Massachusetts, where similar weather conditions prevailed, that relatively few eggs were deposited in either of the two generations of the insect in Connecticut in 1941 as compared with previous years of higher infestation. Weather conditions unfavorable to oviposition and survival of the moths were believed primarily responsible for the low infestation.

Other fluctuations in fall abundance of the corn borer in Connecticut can be associated with the weather. Baker and Vance (2) stated that

". . . . In Connecticut the increased corn borer infestation in 1937 over 1936 was due principally to an extremely heavy deposition of second-generation eggs, indicative of moisture and temperature conditions in the field favorable to the moths during oviposition. Deposition of first-generation eggs and larval establishment in both generations, near New Haven, Conn., were practically the same in 1937 as in 1936."

Although not indicated by the borer population determined in the fall of 1939, the early part of that year was apparently one of the most favorable for the insect among those studied. The heaviest oviposition by first-generation moths during the period 1934-40 occurred in 1939, and about three-fourths of the eggs were deposited during warm dry weather in the first half of June. Preceding this, however, the borer had been exposed to above-normal moisture conditions in March and April and to a very dry May.

Weather conditions in Connecticut for most of the seasons studied were relatively favorable to the borer, and fluctuations in the data for a number of years were not extreme. For example, as noted earlier in the discussion, the number of egg masses per 100 plants in the first generation at New Haven from 1935 to 1940, inclusive, except in 1939, when a real increase in oviposition occurred, remained relatively constant. Somewhat greater variation in egg deposition occurred in the second generation during the period 1935-38. The borer populations (larvae per 100 plants) resulting from such oviposition also held within a comparatively close range, again excepting the first generation in 1939. It is of interest to observe the consistency in the average numbers of borers produced from an average egg mass in the first generation for the six years 1935-40 and in the second generation for the four years 1935-38. In chronological order the ratios for these years were as follows: First generation, 4.1, 4.3, 4.5, 5.4, 5.8 and 5.7; second generation, 3.7, 4.7, 4.3 and 3.3.

This brief analysis indicates the delicate balance of the numerous factors known to influence the corn borer in nature and emphasizes the difficulty, if not the impossibility, of associating weather with borer abundance in an adequate manner entirely free of rationalization, except in *extreme* seasons when the absence or presence of rainfall, or possibly some other factor, becomes a striking feature of the weather. As other studies have shown, moisture appears to be the governing factor in the borer's environment, but once more the difficulty of finding a quantitative measurement of its operation is very apparent.

Summary

The European corn borer, *Pyrausta nubilalis* (Hbn.), was found for the first time in Connecticut in 1923 and had spread over most of the State by 1929. Since 1933 the borer has been a serious economic pest of both field and sweet corn in Connecticut, increasing in abundance until in 1938 the fall population in Hartford County averaged as high as 11.3 borers per plant. In 1939 20 larvae per plant, on the average, occurred in early market

sweet corn in New Haven County. Both the first and second generations of the borer in Connecticut also infest the plants of white potatoes but cause little economic loss to the crop.

As a rule, the corn borer has two complete generations annually in Connecticut. The overwintered larvae pupate at New Haven near the end of April, moth emergence follows about the middle of May, and most of the oviposition by moths from overwintered larvae occurs during June. The first-generation larvae pupate in the field in July, and the emerging moths of this generation deposit their eggs throughout August. The full-grown borers of the second generation hibernate in the field.

The average numbers of first-generation egg masses per 100 plants on early sweet corn at New Haven in the years 1935-38 and in 1940 were rather constant, ranging from 149 in 1938 and 1940 to 178 in 1936. In 1939 the average number of first-generation masses was 406. In the second generation the average numbers of egg masses per 100 plants on late sweet corn at New Haven in the years 1935-38 were 379, 210, 716 and 568, respectively. Almost three times as many egg masses were deposited by moths of the second as by those of the first generation on the basis of population per 100 plants, without regard to differences which might exist between acreages of early and late corn in Connecticut.

The incubation period of eggs of the first and second generations in the field in Connecticut averaged 7.3 and 5.6 days, respectively. An average of 93.8 per cent of 2,171 egg masses observed at Hartford and New Haven in 1934-36 were deposited on the under surfaces of the corn leaves. The average egg mass of the first generation contained 16.2 eggs and that of the second generation, 18.7 eggs.

Daily observations of marked egg masses at Hartford in 1934 and at New Haven in 1935 and 1936 showed that 74.2 per cent of all the eggs hatched normally. A small portion of the eggs were infertile and a few dried up. About 4.5 per cent of the eggs were parasitized by *Trichogramma* sp., and an average of 2.7 per cent were destroyed by predators. Less than one-third of the loss of borers that might have become established in the plants occurred in the egg stage. Larval survival in early sweet corn in Connecticut in the first generation for the seven years 1934-40 averaged 29.5 per cent, and in the second generation for the four years 1935-38 it averaged 21.7 per cent.

A study of the Connecticut data showed a close relationship between egg and larval populations, the number of larvae per plant increasing with increased numbers of eggs per plant, regardless of survival rates occurring in the more or less average years included in the study. Within the limits of the data, this association can be expressed as a straight line which would curve sharply downward if projected to a zero point.

Survival of larvae from the eggs was reduced from 37.7 per cent to 19.9 per cent as the average number of eggs per plant increased from 17.5

to 134. After this the reduction in survival from additional eggs became more gradual, never going below 15 per cent in the data studied.

Weather, particularly the moisture factor, was probably the principal influence affecting populations of the borer in Connecticut. Nevertheless, a satisfactory explanation and measurement of its operation, except in *extreme* seasons, continued to be difficult. The general decrease in borer populations in 1941 from 1940 was attributed largely to a warm, dry spring followed by cool rains which affected adversely an early emerging moth population. On the other hand, in 1939 the borer was exposed to above-normal moisture conditions in March and April which were apparently conducive to a favorable reaction of the insect in the warm, dry May and June which followed. The result was one of the most severe known infestations by the first generation in early sweet corn.

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SQUASH VINE BORER

Raimon L. Beard

To verify earlier observations on the effect of planting date on yield of winter squash and on the control of the squash vine borer by the use of rotenone, plantings of blue Hubbard squash were made on three different dates, and half of each planting was treated with a one per cent rotenone dust, with Bancroft clay as a diluent.

A field approximately one-third of an acre in extent was divided into 48 randomized plots. In each plot were planted six hills, and seedlings were thinned to three plants per hill. Half of the plots alone is considered in yield data, as the other half was reserved for the determination of the borer populations.

Plantings were made on May 1, May 20 and June 10, and the dust was applied at weekly intervals beginning June 30. Five applications were made, but at the time of the fifth application the squash foliage was so dense that probably little of the dust reached the stems, where alone it is effective. Plots for treatment were replicated four times for each planting, and the same number of check plots was maintained.

Dissections were to have been made when the borer population was at a maximum; i.e., after the bulk of the eggs had hatched but before many borers left the vines to enter the soil. After the dissection of one series, however, heavy rains prevented further observations until after the bulk of the borers had left the vines. The borer population as observed in the one series is as follows:

NUMBER OF VINE BORERS PRESENT PER PLOT
(approximately 18 vines)

Date of planting	Treated	Untreated
May 1	14	89
May 20	15	41
June 10	5	16

The reduction in borer population due to treatment is obvious, and it appears that the earlier the planting, the larger the number of borers present.

The yields in pounds of Hubbard squash for each plot are tabulated below:

POUNDS OF SQUASH YIELDED PER PLOT
(approximately 18 vines)

Date of planting	Treated		Untreated	
May 1	136		96	
	153		128	
	216		126	
	101		113	
		606		463
May 20	216		68	
	51		106	
	166		107	
	203		104	
		636		385
June 10	115		122	
	96		102	
	202		68	
	53		96	
		466		388
Total		1,708		1,236

Statistical analysis of variance indicates a highly significant difference between the yields of the treated plots and the untreated, but the differences due to different planting dates are not significant. There is, however, a significant interaction between treatment and dates of planting.

Thus it appears that in the untreated plots, the higher yield of the first planting (even though not significantly higher) was obtained in spite of a much heavier population of borers, presumably because by the time the borers were present the vines had reached such a size as to be able to withstand much of the injury.

On the other hand, among the treated plots, there is a suggestive, if not significant, difference between the yield of the third planting and each of the other two, indicating that possibly the borer population in the third planting was so low that the insecticidal treatment had less effect than on the earlier planting in producing higher yields. Indeed, the difference in yield between the treated and untreated plots in the third planting alone is not statistically significant. It is believed that the reduced yield here is due not to vine borer injury, but to the shorter growing season because of the late planting date.

Thus, although the differences are not as discrete as would be desired, in general, previous observations are supported, and the following conclusions are suggested.

The use of a one per cent rotenone dust is an effective control measure against the squash vine borer, particularly on earlier plantings when the borer population is high. At the present time the use of rotenone on squash and other cucurbits is forbidden by order of the War Production Board, except in small quantities by the home gardener. When rotenone again becomes available, the use of a pyrophyllite diluent instead of Bancroft clay might increase its effectiveness still more.

When no insecticide can be used on the winter types of squash, early planting enables the vines to reach a size able to resist much of the injury caused by the vine borer. Later plantings have fewer borers and consequently less injury, but the shortening of the season results in a decrease in yield of mature fruits. The resistance of the larger vines depends upon vigorous growth and the development of an abundance of nodal roots which are able to support the vines if the main basal root is destroyed by the borer.

RELATION BETWEEN NUMBER OF INSECTS AND DAMAGE TO PLANTS

NEELY TURNER

The effect of insecticides in field control of insects may be measured in two ways: (A) the mortality of the insects and (B) protection of the plants from damage. In the course of dosage studies used to compare two diluents for derris, it was noted that the dosage-response curves for protection of bean foliage from injury were much flatter than the curves for actual control of insects (Turner, 2). In other words, the effect of a change in dosage was much less marked when damage to the foliage was the measure. Information on the reasons for this difference is essential to proper evaluation of dosage-response experiments, because in many cases it is very difficult to determine the mortality of the insects with accuracy.

In the experiment in question, the damage was estimated by a scoring system. Horsfall and Heuberger (1) have demonstrated the precision of this type of estimate by comparing estimates of infection of tomato foliage by *Alternaria solani* with counts of leaves killed and fruits with stem-end rot. They conclude that the method of estimating is "valid, precise and sufficiently objective."

The next point to consider is the relation between number of insects and amount of damage. The bean beetle experiment mentioned previously (Turner, 2) included five concentrations of derris and of pyrethrum, and six treatments of derris dust applied at different amounts per acre, as well as an untreated check. The number of larvae surviving treatment has been summarized by treatments and amount of damage in Table 29. The arrangement is in order of surviving larvae without regard to treatment. When plotted arithmetically these data suggest the upper part of a sigmoid curve. They were therefore plotted on the logarithmic probability grid (Figure 8) and fit a curve reasonably well with one exception. The

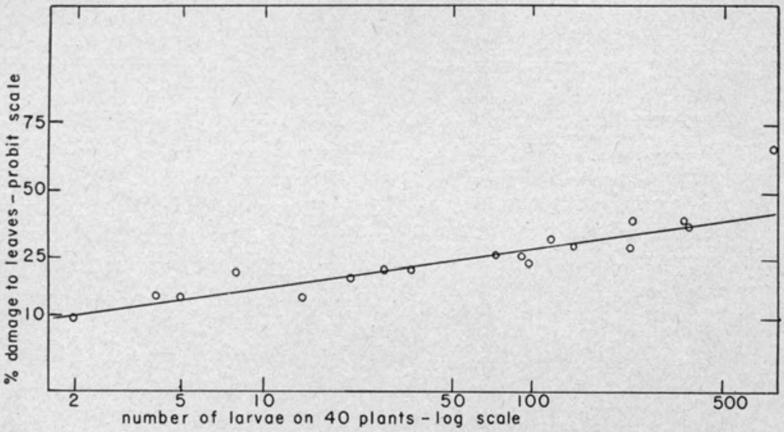

FIGURE 8. Relation between number of larvae surviving treatment and damage to foliage, second-generation Mexican bean beetle, 1942.

untreated check shows much more damage than expected on the basis of the relationship between number of larvae and damage on treated plants. Larvae surviving two applications of dust might not cause the same amount of damage as the same number of larvae developing undisturbed by treatment. Further, the counts were numbers of larvae with no reference to size.

These counts were made three days after the final treatment (August 18). The relative amount of damage at the time was low—in no case except the check was more than 40 per cent of the foliage destroyed. The large amount of damage done by only two survivors on 40 plants (9.38 per cent) deserves comment. This included the damage done by the entire infesting population up to the first (August 8) treatment, and the newly hatched or surviving larvae between August 8 and 18.

TABLE 29. LARVAE AND DAMAGE, SECOND-GENERATION BEAN BEETLE TESTS, 1942

Number of larvae surviving on 40 plants	Per cent damage to foliage
2	9.38
4	13.75
5	13.75
8	20.0
14	13.75
21	18.75
28	20.63
35	20.63
90	25.63
96	23.75
117	31.88
138	28.75
227	28.75
228	38.75
353	38.75
370	36.25
757	67.5

In a first-generation (1942) test of dosages of pyrethrum and derris on bean beetles, applications were made May 28, June 16 and June 26. Surviving larvae were counted June 29 and 30. The crop was harvested July 1 to 3, and the amount of damage to bean pods recorded. The pods were sorted immediately after picking, and all pods with any feeding marks weighed separately. Table 30 and Figure 9 give the results summarized

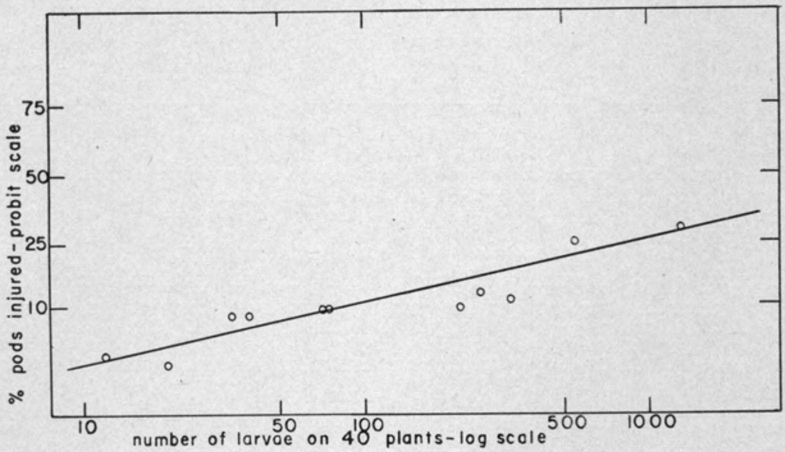

FIGURE 9. Relation between number of larvae surviving treatment and damage to bean pods, first-generation Mexican bean beetle, 1942.

for treatments. The trend here is exactly the same as in the case of damage to foliage. Large increases in numbers of surviving larvae produced only a small amount of additional damage to pods.

TABLE 30. LARVAE AND POD DAMAGE, FIRST-GENERATION BEAN BEETLE TESTS, 1942

Number of larvae surviving on 40 plants	Per cent pods injured (by weight)
12	3.9
20	3.1
34	8.1
35	9.4
38	8.1
71	9.1
74	9.1
216	9.5
254	11.8
321	10.6
544	24.6
1285	29.1

Discussion

In both of these cases the curves are very flat, indicating a comparatively small increase in amount of damage as the number of insects is increased. The effect of increasing populations appears to be logarithmic rather than arithmetic. The percentage of damage can be expressed by probability units. With such a relationship it is to be expected that dosage-response curves for insect damage should be much flatter than those for insect control. In Figure 8, 10 larvae surviving on 40 plants were associated with 16 per cent damage, and 100 larvae with 28 per cent damage. Increasing the number of survivors by 10 times resulted in only 12 per cent additional damage. In Figure 9, 10 larvae surviving on 40 plants were associated with 3 per cent of damaged pods, and 100 larvae with 10 per cent and 1,000 larvae with approximately 25 per cent.

It must be emphasized that these relationships refer to larvae *surviving* treatment in all cases except one untreated plot in each test. The amount of damage was influenced by the number of larvae actually killed. It is also probable that treated plants were protected to some extent by the residues on the foliage. Both factors affected the amount of damage, and the results include them both. The results cannot be interpreted as measuring the amount of damage done to plants by these same numbers of larvae in the absence of treatment.

Summary and Conclusions

Dosage-response curves in which response is measured as damage to plants are much flatter than those in which response is measured as insect mortality. This is explained by the relation between number of insects and damage to plants, which in itself appears to be analogous to dosage of insecticides and mortality.

In practice, either method of determining response should be acceptable, but damage to plants appears to be of more importance than insects killed.

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EFFECT OF DOSAGE OF INSECTICIDES ON FIELD CONTROL OF VEGETABLE PESTS

Neely Turner

The effect of dosage of insecticides on the degree of control of insects is of fundamental importance. At present there is added interest in the method of meeting shortages of insecticides by reducing the dosage applied. Turner and Horsfall (5) have discussed briefly some of the factors involved and cited experiments to show the relatively small average loss in control resulting from comparatively large reductions in dosage.

During the season of 1942, experiments were conducted to obtain further information on the effect of dosage on control of insect pests of vegetables.

Methods

Dosage as used here may be defined as the amount of toxicant applied per acre. There are three ways of changing dosage: (A) a change in the number of applications, which involves both dosage and timing, (B) a change in the amount applied per acre with the concentration kept constant, which involves both dosage and coverage and (C) a change in concentration with the total amount kept constant. This last method was used in all tests reported here. It involves both dosage and any effect of changing amounts of dust diluents on the toxicant. While effect of amount of diluent on toxicant is not to be ignored, it is certainly less complicating than coverage or timing. As a rule the highest dosage was twice the standard amount usually used, followed by the standard concentration, one-half, one-fourth and one-eighth of the standard. Such a range was sufficient to cover dosages of practical value and to establish a reasonably accurate relationship between dosage and control.

In reporting results, the concentration of active ingredient has been used as the dosage. There is no simple method of measuring the quantity of dust actually reaching the plants. It is assumed that the same proportion of each concentration reaches the plants and therefore the concentrations can represent dosage.

All tests were made on small field plots, randomized in blocks and replicated at least four times. Treatments were made with hand equipment at the time suggested for applications in vegetable pest control schedules. The results were obtained by comparing the number of insects surviving treatment with the number on untreated plants. Sample plants were taken at random from each plot.

Entomologists accustomed to the use of the arithmetic scale in plotting dosage-response data are familiar with the resulting sigmoid curve. Such a curve demonstrates the very small gain or loss in response by increase or decrease in dosage at high levels of control, where the slope of the curve is very flat. It can also be used for comparisons of materials but is less useful than the method of Bliss (1) in which dosage is plotted as logarithms and control in probits. This method can be used very easily by plotting on logarithmic probability paper. It was designed originally for laboratory data, but has been applied successfully to field results by Dimond et al. (2) and Turner (3). The advantages of this method are (A) the resulting curves are usually straight lines—if they are not, an important and unusual effect is indicated, (B) it is considerably easier to interpolate on such a straight line and (C) statistical analysis (if desired) can be made to establish the slope and position of the curve and to compare materials on this basis rather than on the basis of individual dosages.

The Cabbage Maggot

Copenhagen Market cabbage plants were set in the field April 30. The plots were of 10 plants each, randomized in each of four blocks. Treatment was made May 1 by placing one teaspoonful of dust (about 1.75 grams) around the stem of each plant. Calomel-clay dust was used in all cases. On May 26 five plants were taken at random from each plot, and counts made of the larvae and pupae on the plant and in the soil nearby. The results are summarized in Table 31 and shown graphically in Figure 10. Yield records were obtained, but the small number of plants involved

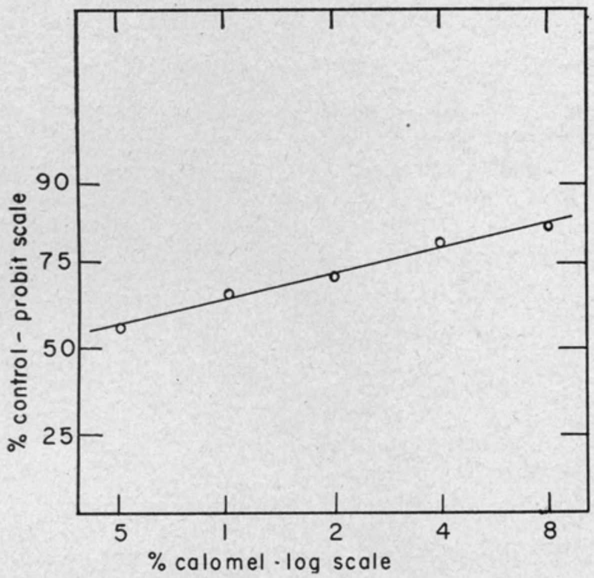

FIGURE 10. Dosage-response curve for surface treatment using calomel at planting time.

prevented any conclusion other than that all treated plots yielded substantially better than the untreated ones.

The results show that the dosage-response curve for control of these insects is relatively flat. In other words, the relative response from a change of one unit of dosage was very small.

TABLE 31. DOSAGE TEST, CALOMEL-CLAY DUST ON THE CABBAGE MAGGOT

Per cent calomel	Number of larvae and pupae	Per cent reduction
.5	74	56.2
1.0	57	66.3
2.0	49	71.0
4.0	35	79.3
8.0	29	82.8
Check	169	

Mexican Bean Beetle

Bountiful beans planted May 1 were dusted on May 28, June 16 and June 26. The rate of application per acre was large, approximately 70 pounds for each application. On June 29 and 30, counts were made of the larvae on 10 plants of each plot. The results are given in Table 32 and

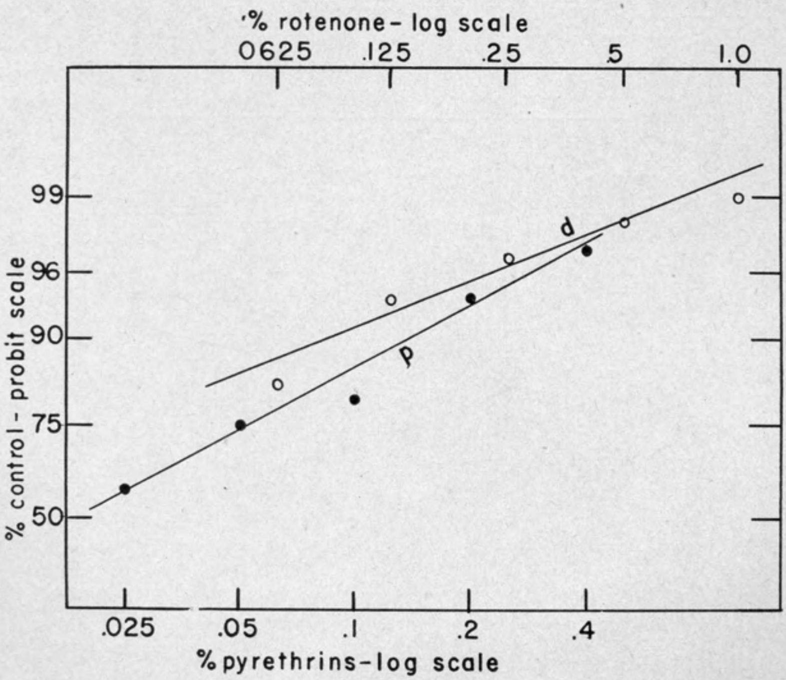

FIGURE 11. Dosage-response curves for impregnated pyrethrum dust (p) and derris (d), first-generation Mexican bean beetle.

Figure 11. Yield records were kept but failed to show any differences attributable to treatment.

The dosage-response curves are relatively flat. In terms of dosage for equal control, at the 90 per cent level for larvae .15 per cent pyrethrins equalled .08 per cent rotenone in derris dust.

TABLE 32. FIRST-GENERATION MEXICAN BEAN BEETLE

Derris and Pyrethrum with Pyrophyllite Diluent

Toxicant	Concentration percentage	Number of larvae on 40 plants	Per cent reduction in larvae
Derris	.0625 rotenone	216	83.2
	.125	74	94.2
	.25	38	97.0
	.5	20	98.4
	1.0	12	99.0
Impregnated pyrethrum	.025 pyrethrins	544	57.6
	.05	321	75.0
	.10	254	80.2
	.2	71	94.4
	.4	34	97.4
None	None	1,285	

Results of similar tests on the second generation of the Mexican bean beetle have been reported (Turner, 4). In this case the amount of dust to the acre was controlled at 24 pounds. Since the two tests were applied at different times no direct comparison of the results is possible. However, there is certainly no evidence that the use of the large amount to the acre invalidated the first-generation test.

European Corn Borer

Tests of dosages of dual-fixed nicotine and derris dust to control the European corn borer have been submitted for publication (Turner, 4). The data obtained will be referred to in Table 33.

Discussion

The results of these tests can be summarized on the basis of the loss in control resulting from a reduction in dosage. There is apparently no standard concentration for some of the materials used. For that reason an arbitrary standard has been selected. The results of all the dosage tests mentioned above are summarized in Table 33, giving the control with the selected standard and with a one-half dose. The difference between these two controls in probits is also included. The table shows percentage differences varying from 1.4 per cent to 19 per cent with one-half the standard dosage. The advantage of the probit calculation is apparent in the last three tests on the Mexican bean beetle. The probit difference was almost identical, but the percentage differences were 6.0 per cent, 15 per cent and 1.4 per cent respectively. The higher the degree of control the less difference in percentage, although the rate of loss in probits was relatively constant.

Table 33. Reduction in Control for One-Half Standard Dosage

Insect	Toxicant		Control: Standard dosage (in percentages)	Control: Half dose (in percentages)	Control: Loss in probits
Cabbage maggot	Calomel dust	4.0	78.0	72.0	.19
Mexican bean beetle	Rotenone-pyrophyllite dust	.5	98.2	96.3	.31
Mexican bean beetle	Pyrethrum-pyrophyllite	.3	96.0	90.0	.47
Mexican bean beetle	Rotenone-clay	.5	87.5	74.0	.51
Mexican bean beetle	Rotenone-pyrophyllite	.5	99.4	98.0	.46
European corn borer	Fixed nicotine	4.0	54.0	35.0	.49
European corn borer	Rotenone-clay dust	1.0	51.0	37.0	.36

In the first test on the bean beetle, 70 pounds of dust were used per acre. The smaller probit loss may be a result of the large amount of dust applied, as compared with later tests.

On the whole these tests indicate that a probit loss of .5 or less may be expected if the dosage of any of these insecticides is to be reduced by one-half. The value of this probit difference in percentage depends on the location on the scale. In the case of the European corn borer, control with the full dosage is obviously very short of ideal. Control with a half-dose is even shorter. On the other hand, in three of the four bean beetle tests and in the cabbage maggot experiment the reduction in dosage did not reduce the control seriously.

This leads to the general conclusion that dosages now providing high levels of control or with very flat dosage-response curves can be reduced drastically without serious loss in degree of control. The percentage difference between full and half-doses of materials providing less effective control is much larger.

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THE JAPANESE BEETLE AND THE ORIENTAL BEETLE

J. Peter Johnson

Japanese Beetle

A small number of beetles were reported feeding on roses June 6, 7 and 8, 1942, at one location in Meriden. Mr. W. T. Brigham of this Department visited the site on June 16 and collected seven adults. As seasonal emergence in Connecticut usually begins between June 20 and 25, the preseasonal appearance of these insects was believed to be due to their early development under favorable soil conditions created by underground steam lines in the vicinity of the property on which the beetles were found.

The seasonal emergence of adults began on June 24, and the insects were becoming numerous by July 1. During the season, visits were made to the Bridgeport, Hartford and New Haven areas to observe the intensity of the infestations and foliage damage. The towns of Bloomfield, Bridgeport, East Hartford, East Haven, Fairfield, Hamden, Hartford, New Haven, Newington, North Haven, Rocky Hill, Stratford, Trumbull, West Hartford and Wethersfield were generally infested with large populations of beetles. Large areas of browned foliage, caused by intensive feeding, were observed in many sections of all these towns. The most intensive feeding occurred in large open turf areas devoid of natural woodland in Rocky Hill and Wethersfield, where practically all existing host plants, including apple, elm and horsechestnut, were defoliated. Small local infestations were found throughout the towns of Glastonbury and Manchester.

The grubs of this insect continue to be the most important turf and lawn pest in the State. Reports of damage and requests for methods of control were received from all areas infested by the beetle. Lead arsenate, applied at the rate of 10 pounds to 1,000 square feet of turf area, the standard recommendation, was used to protect several hundred acres of turf during the season.

Oriental Beetle

The oriental beetle, *Anomala orientalis* Waterh., was reported for the first time from the towns of North Haven and Woodbridge. The larvae or grubs were destroying the turf in lawns. A number of lawns were also damaged in New Haven and West Haven.

In the fall of 1941, potatoes were injured in a field in Hamden by grubs of this insect. This was reported in the Forty-First Report of the State Entomologist. Peas, beans and squash were planted in the same field in the spring of 1942 and a large number of plants of these crops were killed, the roots having been eaten by the Anomala grubs. The field was plowed and harrowed on June 6 and 7, when the majority of the insects were in the prepupal and pupal stages. Numerous blackbirds and sparrows were following the plow, eating all of the insects which were exposed in the turning of the soil.

THE DUTCH ELM DISEASE SITUATION IN CONNECTICUT

R. B. FRIEND

The Present Status

The Dutch elm disease has become a serious problem in Connecticut since it was first discovered here in 1933. Thousands of elms have died of the disease in this State, and unless the progress of the infection is stemmed, many more will die during the next few years. The elm is our most valuable shade tree, and its preservation is a matter of vital concern to every citizen.

The disease was first found in this country in Cleveland, Ohio, in 1930. During that year and the next, eight infected trees were cut down and destroyed. This minor outbreak was apparently checked. In 1933 a serious outbreak was found in an area centering in New York City and extending into Staten Island, Long Island and Westchester County, New York, and the northern part of New Jersey.

Vigorous attempts were made by state and federal authorities to stamp out the infection by cutting down and destroying all diseased trees, and by enforcing a quarantine. This attempt has not succeeded and the disease has spread generally in New Jersey, eastern Pennsylvania, southeastern New York and that part of Connecticut west of the Connecticut River. There are also isolated centers of disease in Maryland, District of Columbia, Virginia, West Virginia, Ohio, Indiana and Massachusetts.

The course of the outbreak in Connecticut is shown on the accompanying map (Figure 12). The date in each town indicates the year during which the first diseased tree was found there. In Preston no indication of infection has been discovered since the first diseased tree was found and destroyed. In Old Lyme the original infection was apparently eradicated in 1937, but in 1942 one more diseased tree was found.

A gradual spread of infection from Greenwich north and east to the Connecticut River has taken place during the past 10 years. Further spread eastward may be slower, as the principal carrier, the smaller European elm bark beetle, is not so abundant east of the River as west of it. This should also aid the attempt of the federal Bureau of Entomology and Plant Quarantine to retard the spread to the east. At the present time this Bureau is operating in a zone about 30 miles wide along the eastern

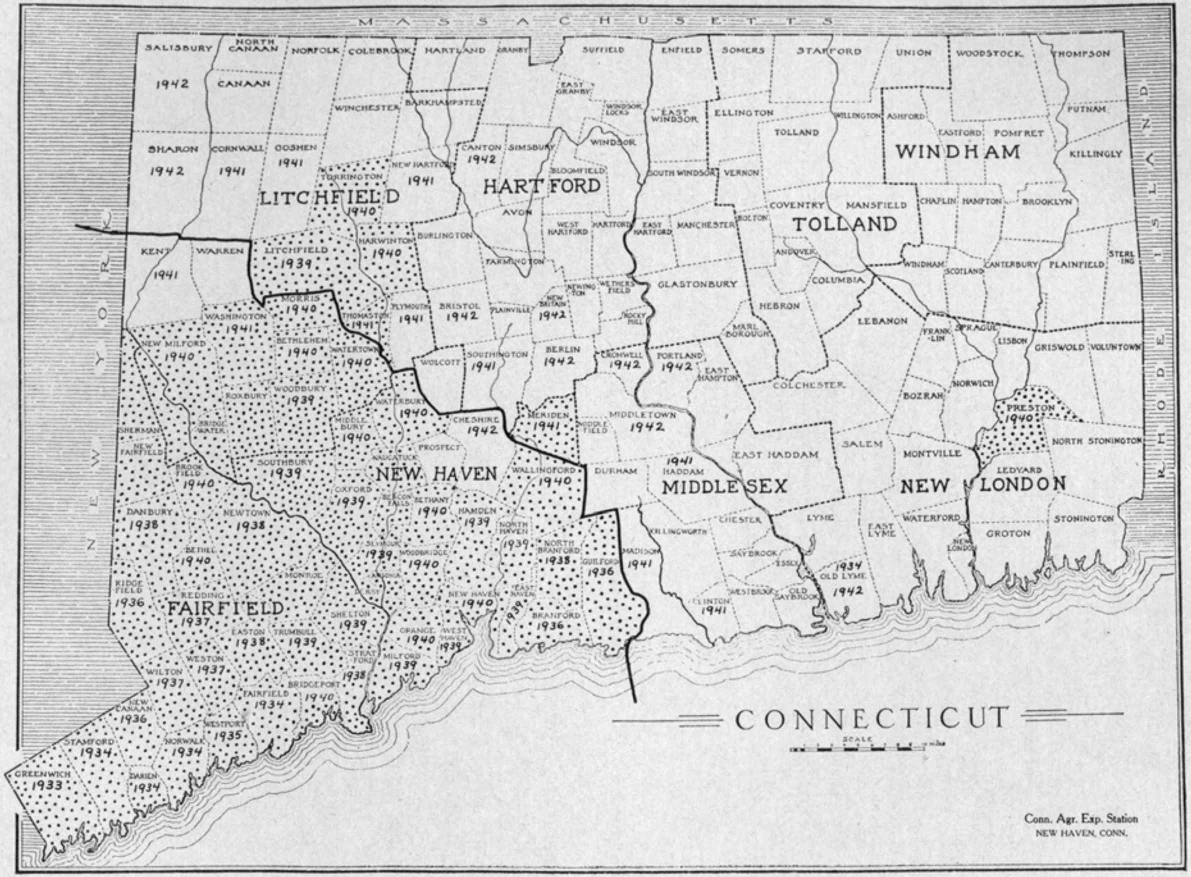

FIGURE 12. Dutch elm disease. The quarantined towns are stippled. The heavy line indicates the western border of the control zone of the federal Bureau of Entomology and Plant Quarantine.

border of the quarantined area and extending approximately from the northwest corner of the State to the mouth of the Connecticut River. In this zone all diseased elms found are cut down and destroyed before bark beetles emerge from them.

Within the generally infected area the intensity of infection is not uniform. The southwestern corner of the State, where the disease has been present longest, appears to be more heavily infected. An examination of the elm trees in parts of Norwalk, Darien, Stamford and Greenwich in the summer of 1942 formed the basis of an estimate of a total of about 1,500 diseased trees standing in these four towns at this time. Up to 1941 the Bureau of Entomology and Plant Quarantine, with the cooperation of this Station, carried out an eradication program in this area. The largest number of diseased trees destroyed in any town in one year was 142 in Stamford in 1938. Taking the State as a whole, the situation is serious in Fairfield County; in Litchfield County occasional diseased trees or infected spots have been found in most of the towns; in New Haven County the disease occurs in nearly every town, although the infected trees found to date have been scattered; the disease is firmly established in five towns in Hartford County, being more prevalent in New Britain than elsewhere; in New London County one infected tree was found in Preston in 1940, but none have been found there since, and one infected tree was found in Old Lyme in 1942; the disease does not occur, to the best of our knowledge, in Tolland and Windham counties.

As far as Connecticut is concerned, we must learn to live with this disease, and our efforts should be concentrated on the reduction of the incidence of disease on our valuable shade and ornamental trees. With proper care a reasonable reduction should be attained.

The federal Bureau of Entomology and Plant Quarantine is now confining its efforts to an attempt to stop the spread of the disease. In Connecticut it operates in a broad zone, mentioned above, bordering the edge of the generally infected area. In that zone all diseased trees are cut down and burned when found.

A federal and state quarantine (Federal Quarantine No. 71, revised October 1, 1941; Connecticut Quarantine No. 37, revised as Quarantine No. 39 effective November 1, 1941) is in effect regulating the movement of elm plants or parts thereof, including articles made of elm wood on which the bark is present, from the western part of Connecticut, as indicated on the map (Figure 12), to any place outside of that part of New Jersey, New York, Pennsylvania and Connecticut now within the quarantined area. This office cooperates with the Bureau in the enforcement of this regulation.

Nature of the Disease

The Dutch elm disease is a vascular disease of elms caused by a fungus, *Ceratostomella ulmi* (Schwarz) Buisman. When an elm tree becomes infected, a toxin is formed which causes the foliage to wilt, and gum barriers and tyloses block the vascular system in the outer ring of wood.

This blocking affects to a limited degree the flow of sap in the tree, but the effect of the toxin is more important. Both phenomena occur at the same time.

The most conspicuous symptoms are the wilting or yellowing of the foliage and the development of a brown discoloration on the surface of the wood just beneath the bark. Early in the season, in June and July, infected trees wilt badly. The foliage over the entire tree may curl and remain on the branches for some time, or it may turn yellow and drop. Frequently only a part of the tree may be affected. During late summer and early fall the progress of the disease is less rapid, and the externally visible symptoms may be confined to a few small branches on which the leaves turn yellow and drop. At this time yellowing of the foliage may be due to other causes, confusing the picture.

The brown discoloration of the outer sapwood just under the bark is a very valuable symptom, although not specific for this disease alone. If an infected branch is cut across, a more or less complete dark ring can be seen in the outer wood. When bark is peeled from such a branch, brown longitudinal streaks are seen on the surface of the wood. The extent of this streaking is indicative of the extent of infection. In some cases it is confined to a single branch, in other cases it extends down the trunk to the ground.

The symptoms described above permit a successful diagnosis in the great majority of cases, but such a diagnosis is not absolutely certain because other diseases of elms produce similar symptoms. It is necessary to make a laboratory culture from a sample of the infected part of the tree in order to positively identify the causal organism.

Although all species of elm may become infected, they are by no means equally susceptible. Certain Old World varieties are resistant, and the infection in them remains localized. These are not, however, as suitable for shade and ornamental purposes as the American elm. This latter species is, unfortunately, very susceptible, although individual trees show much resistance, the mechanism of which is not known. Vigorous growth does not aid a tree in throwing off the effects of the fungus, but it is indirectly favorable because such a tree is not attractive to bark beetles.

Transmission of the Disease

The disease is transmitted to healthy elms in this country by two species of elm bark beetles, the smaller European (*Scolytus multistriatus* Marsh.) and the native (*Hylurgopinus rufipes* Eich.). The former is by far the more important. These beetles breed in dead or dying elm wood only. This may be the trunk and branches of a declining tree, a broken or dying branch on an otherwise healthy tree, or an elm log on the ground. The adults bore into the bark of such material during the period from May to September and make tunnels in the inner bark, scoring the outer wood. Eggs are laid in the tunnels and the larvae which hatch from these eggs bore away from the maternal tunnel. When they have completed their development they change to pupae in cells in the inner bark. The pupae transform into adult beetles which bore out and fly away. The European species has two generations a year and hibernates in the larval stage. The native beetle has one complete and one partially complete generation a year and hibernates either as a larva in the brood tunnel or as an adult in a hibernating tunnel in the bark of a living tree or a log.

In addition to making their breeding tunnels, these two beetles penetrate into the bark of healthy elms for the purpose of feeding. When the adult of the European elm bark beetle emerges, it flies to a healthy elm and bores into the crotches of twigs in a very characteristic manner before going to a suitable breeding place. This twig crotch feeding takes place near the breeding material, either that from which the beetles emerge or that which they will enter. The native elm bark beetle has also been known to feed in twig crotches, but this is by no means common. Feeding tunnels are usually made in the bark of the trunk and branches of healthy elms by this latter species, and when such tunnels occasionally contact the outer sapwood it is possible for infection to take place.

For all practical purposes, the wounds made by bark beetles are the only places of inoculation. If a tree or log on the ground is infected with the disease and bark beetles breed therein, the fungus occurs throughout the beetle tunnels. When the adult beetles emerge, the sticky spores of the fungus adhere to their bodies. Another tree or log becomes infected when these beetles bore in for the purpose of feeding or laying eggs. A healthy elm thus infected dies and becomes a suitable breeding place for more beetles and hence a source of inoculum. A vicious cycle is formed; the disease kills the tree and the latter becomes attractive to beetles. Any cut elm wood or dying branch which has not dried out is attractive as a breeding place and it also develops into a source of inoculum after spore-bearing beetles attack it.

Control Program

It appears practically impossible to eradicate this disease from Connecticut, and it may be impossible to stop its eventual spread into the eastern part of the State. The problem, then, becomes one of protecting valuable trees in localities where the disease occurs. There is good evidence that such a program, energetically and carefully carried out, will be well worth while. It involves the prompt destruction of badly diseased trees and the elimination of all elm material in which bark beetles may breed in any area where valuable elms occur. The prevalence of the disease depends on the abundance of bark beetles and the presence of infected wood.

All elm trees should be kept in a healthy condition in order that bark beetles will not breed in them. They should be protected from the attack of injurious insects and diseases and, if necessary, watered and fertilized. All dead and dying branches should be removed as soon as discovered.

If no dead or dying elm wood in which beetles may breed occurs within about 500 feet of valuable elm trees, and all diseased elms within this area are cut down and burned as soon as found, then the chances of such valuable elms becoming infected are reduced to a minimum. If it is desirable to use elm wood, then it should be barked, sprayed with creosote,[1] or stored in a tight compartment from which beetles cannot emerge. Under no conditions should untreated elm wood be allowed to remain out-of-doors between May 1 and October 1, nor should any badly diseased tree be allowed to stand lest a bark beetle brood develop in it.

If an infection occurs late in the season, after about the middle of August, and is confined to a few small branches, then these may be cut off close to the main branch or trunk, well beyond the characteristic brown discoloration in the outer wood, and burned.

A prompt diagnosis is essential. Elm trees should be carefully examined twice each year, once during the first half of July and again during the last half of August. If the typical foliage symptoms are noticed, then the bark should be stripped from parts of the affected branch and the exposed wood examined for brown discoloration. If a small infected branch is cut off, a brown ring, often discontinuous, can be seen on the cut surface close to the bark. When this discoloration is found, samples of small infected branches should be sent to the Experiment Station for laboratory culture. These samples, about six in number, should each be about six inches long and one-half inch thick. The Experiment Station will notify the sender whether or not the disease is present. As far as possible, members of the Station staff will examine suspicious elm trees on request and recommend the proper procedure should any doubt arise in the owner's mind.

If the town officials will properly care for street trees, and private citizens care for those on their own property, a marked improvement over the present situation should result. The loss of a tree occasionally is to be expected, but the death of large numbers of trees within a short time is preventable. A letter has been sent to the first selectman or mayor and also to the tree warden of each town or city in the State, informing this official of the situation as it exists in his community and urging a community effort to suppress this disease.

The Agricultural Experiment Station has been interested in this problem since the first diseased tree was found in the State. It has investigated the pathological aspects of the disease and the relations of bark beetles to it, and has cooperated with the federal Bureau of Entomology and Plant

[1] Entomologists of the federal Bureau of Entomology and Plant Quarantine have found that a mixture of 1 part orthodichlorobenzene and 4 parts light fuel oil, by volume, is an excellent bark beetle repellent and will also kill most of the beetles present in logs if applied during warm weather. After either this material or creosote is applied, the wood should be allowed to remain out-of-doors several weeks before being stored inside or used. When elm wood is burned three to four months after treatment the disagreeable handling condition and odor are practically dissipated.

Quarantine in its control work and quarantine enforcement. The Station's investigations, which aim at improving methods of control, are being continued by the Departments of Entomology and of Plant Pathology.

A bibliography of the papers published by members of the Station staff is given below. In addition to this, notes on recent entomological investigations are included in this Report.

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DUTCH ELM DISEASE SAMPLE PLOTS, 1942

PHILIP P. WALLACE AND DOLOR LABELLE

The last comprehensive scouting and eradication of Dutch elm disease (*Ceratostomella ulmi*) in lower Fairfield County was carried out by the U. S. Bureau of Entomology and Plant Quarantine in 1940. Since then many infected elms have been removed as soon as they were discovered, particularly in Greenwich and Stamford, but little has been known about the total number of elms removed or the actual status of the disease during these two years.

The Dutch elm disease was first discovered in Greenwich, Stamford, Darien and Norwalk in 1933 and 1934, and it is now firmly established there. To determine the number of infected elms in these towns in the summer of 1942, five plots, each one-quarter of a mile square, were chosen at random in each of them and these areas were thoroughly scouted and sampled. Since the total area scouted in each case represents 3 to 4 per cent of the area of the town (average 3.9 per cent) and there are five subsamples each, the sampling is adequate statistically and there is a satisfactory basis for estimates.

The survey was carried out from June 26 to August 10. Only those elms which showed definite signs of wilting or yellowing foliage or completely defoliated twigs were sampled. An occasional dead tree was also included. Exceptionally heavy elm leaf beetle and Japanese beetle feeding interfered with observations. Elms showing certain definite symptoms were not sampled, resulting in conservative figures for the estimates that were calculated.

All elms 2 inches in diameter and over in the sample areas were counted, and the average per cent in each group size was as follows:

D.B.H. of Elms Inspected

2–6 inches	58 per cent
6–12 inches	25 per cent
12–24 inches	10 per cent
24+ inches	7 per cent

Tables 34, 35 and 36 give the incidence of disease and other pertinent data.

TABLE 34. DUTCH ELM DISEASE INCIDENCE IN SECTIONS OF FOUR TOWNS IN FAIRFIELD COUNTY, 1942

	Scouted area sq. mi.	Total elms	Number diseased
Norwalk			
Section 1	.22	234	1
" 2	.21	226	3
" 3	.20	613	1
" 4	.23	40	0
" 5	.18	70	5
Darien			
Section 1	.20	215	6
" 2	.25	217	7
" 3	.25	239	1
" 4	.27	359	5
" 5	.25	90	1
Stamford			
Section 1	.27	375	9
" 2	.26	250	6
" 3	.25	379	3
" 4	.25	213	1
" 5	.25	224	0
Greenwich			
Section 1	.24	592	5
" 2	.31	387	0
" 3	.25	194	0
" 4	.20	242	3
" 5	.15	235	3

TABLE 35. DUTCH ELM DISEASE INCIDENCE IN FOUR TOWNS IN FAIRFIELD COUNTY, 1942

	Sq. miles scouted	Town area sq. mi.	No. of elms infected	Elms infected per sq. mi.	No. elms in sect.	Estim. total elms	Percentage of elms infected	Estim. total trees infected
Norwalk	1.04	24.6	10	9.6	1,183	27,993	0.84	236
Darien	1.22	14.9	20	16.0	1,120	13,664	1.8	244
Stamford	1.28	38.1	19	15.0	1,441	42,798	1.31	564
Greenwich	1.15	42.7	11	9.6	1,650	61,215	0.66	408
Total	4.69	120.3	60		5,394			

A consideration of the number of diseased elms found and removed in these four towns in the eradication program of the United States Department of Agriculture, since the first infected elm in Connecticut was found in 1933 through 1940 when the work was discontinued, offers a comparison with the data for 1942. Due to private enterprise some additional diseased elms have been removed, particularly during the past three years. These were not recorded.

TABLE 36. NUMBER OF DISEASED TREES IN FAIRFIELD COUNTY, 1933–42

	Greenwich	Stamford	Darien	Norwalk
1933[1]	1	—	—	—
1934[1]	35	9	8	1
1935[1]	34	27	6	4
1936[1]	63	11	9	7
1937[1]	63	27	24	2
1938[1]	137	142	66	58
1939[1]	80	100	29	41
1940[1]	49	32	16	51
1942[2]	408	564	244	236

[1] Removed by U.S.D.A.
[2] Estimated standing in summer.

The trend of the disease is difficult to characterize, and due to the limited amount of precise information available any explanation or prediction would be only conjecture. It is nevertheless apparent that with the cessation of major control activities in these towns, marked increase in Dutch elm disease incidence has occurred.

In addition to random plot sampling for the Dutch elm disease in the above-mentioned towns in Fairfield County, a number of other plots were examined. The plot locations were determined by drawing a diagonal line on a map from Greenwich to Thompson. The center of the section of the line as it passed through each town was taken as the center of a sample block, one-quarter of a mile square. It is proposed to retain these as permanent plots for annual scouting for the purpose of indicating any general tendency of the Dutch elm disease to spread toward the northeast. Incidentally, the line when extended passes through New York City and Boston. No infected elms were found in any of these sample areas during 1942.

Town	No. elms in plot	Town	No. elms in plot
Trumbull	79	Hebron	38
Shelton	46	Andover	77
Ansonia	154	Coventry	251
Woodbridge	71	Mansfield	150
Hamden	169	Ashford	36
Wallingford	44	Eastford	130
Meriden	156	Pomfret	225
Middlefield	—	Woodstock	115
Middletown	555	Thompson	121
Portland	172		

CHEMICAL REPELLENTS TO BARK BEETLE BREEDING

PHILIP P. WALLACE

Further investigations of chemicals which may be of practical use in repelling bark and wood-boring insects when applied to the bark of cut elm logs are reported here.

During the spring of 1941 the Dutch elm disease unit of the U. S. Bureau of Entomology and Plant Quarantine sprayed several cords of freshly cut elm wood in the Town of Wallingford, Conn., with a solution of one part orthodichlorobenzene to four parts of fuel oil. Certain observations of the project were made by this Station. The types of material treated were: entire down trees, elm piles and mixed cordwood piles in which elm constituted about 10 per cent of the total. Although logs were not moved, all elm was sprayed with a hand pump as thoroughly as practicable. Light creosote oil was applied in the same manner for comparison. A large population of overwintering *Hylurgopinus rufipes* Eichh. adults was present and there was a light infestation of *Scolytus multistriatus* Marsh. larvae near the plot.

The data taken from samples from all the treatments are omitted in this report. The orthodichlorobenzene-oil solution was found to be completely satisfactory as a repellent to bark beetle attack on the surface where it was applied, but, like creosote, its repellence to beetles attacking logs quite close but unsprayed is limited to a week at most. A month after treatment there was no significant difference in the attack to the inner logs of a pile, regardless of whether or not the outside logs were sprayed. Treating part of a log did not affect bark beetle attack on the rest of it after a few days when the volatile gasses were dissipated.

Since bark beetles are rarely found breeding in the upper quadrant of elm logs it is unnecessary to spray this area. Entirely satisfactory control was obtained in these tests by spraying the upper half of logs 12 inches in diameter and rolling them over a few minutes later. The run-off usually covers the lower sides and no consideration need be given the untreated part which becomes the top quadrant when rolled.

The only borers which were observed to penetrate bark treated with this material were a few *Anisandrus sayi* Hopk. and *Xyloterinus politus* Say adults. Both these species of ambrosia beetles have been noted on one occasion boring through creosoted bark.

The proprietary compound Permasan, containing pentachlorphenol as the active ingredient, was evaluated as a bark beetle repellent in other tests. This material is reported to be widely used, considerably diluted with a special type of light fuel oil by a patented process, as a wood preservative for controlling mold, mildew and decay fungi in lumber. Wood products are dipped or sprayed. Its use in the control of powder-post beetles and other wood-boring insects has been reported by others.

In an area where infestation by *S. multistriatus* was known to be severe, three elms standing a few feet apart were felled in June, 1941. The trunk of tree A was immediately sprayed with Permasan and 7 feet of the trunk of C was sprayed with light creosote oil. After B became heavily infested with *S. multistriatus* one month later, a section of the trunk was sprayed with Permasan, another with creosote and a section between the treatments was left as a control. Other controls noted were bark areas directly above or below the treatments.

Table 37 is a record of the results of treatments, taken when the trees were examined in October.

TABLE 37. CHEMICAL TREATMENT OF ELM WOOD

	Diam.	Length	*S. multistriatus* galleries	Condition of larvae	Notes
Treated when cut—					
A Permasan	5½ in.	14 ft.	0	—	Cerambycid and buprestid larvae common, alive
A Control	3¼ in.	18 in.	12	Normal	*Magdalis* larvae abundant, normal
C Creosote	3 in.	7 ft.	0	—	No attack
C Control	3½ in.	36 in.	2	Normal	Cerambycid, buprestid and *Magdalis* larvae common, alive
Treated after infestation—					
B Permasan	4½ in.	29 in.	99	All dead	2 cerambycid and 8 *S. multistriatus* larvae[1], alive
B Creosote	4¼ in.	25 in.	85	All dead	1 cerambycid and 1 *Magdalis* gallery, all dead
B Control	4½ in.	12 in.	68	Large emergence, normal	Cerambycid and buprestid larvae common

[1] These larvae had come from untreated bark area adjoining.

Permasan sprayed on the bark surface was effective in killing all species of insects noted under the bark and in the outer sapwood. In this test there was no subsequent attack by bark beetles although there was a heavy attack by cerambycids and buprestids. The various species present were not determined. The exceptional penetrating properties of Permasan and its lethal effect on plant and insect life indicate that it may be quite effective in destroying all stages of wood borers when applied to sawn lumber. Its repellence to insects may be specific for certain species and this should be investigated for the species concerned.

Conclusion

Recent investigations have demonstrated that elm bark beetle attack on freshly cut elm logs may be prevented by applying to the surface of the logs certain chemicals, i.e.: light coal tar creosote, orthodichlorobenzene and fuel oil, and Permasan (pentachlorphenol and oil). These repellents are effective only on the bark area wet with the chemical. The top quadrant of logs in sunlight can be omitted from treatment. Spraying of the top half followed by rolling the log will accomplish this economy.

Coal tar creosote—the most effective repellent to insect attack tested, relatively inexpensive; available in this locality; disagreeable to handle, and caustic to skin, especially so to the eyes; objectionable stain and residue.

Orthodichlorobenzene—effective; available; fairly expensive; less disagreeable to handle and less caustic than other chemicals reported; no residue.

Permasan—effective only against bark beetles in these tests; transportation expense results in high cost in New England when purchased ready-mixed; quite caustic to skin; vapors caustic to eyes and nasal passages; no residue; gives excellent penetration.

Numerous trials of the effectiveness of these chemicals in killing bark beetle broods under the bark have indicated that the condition of the bark and of the beetle entrance holes greatly influence the penetration of the chemical. Frass, dirt, decayed bark and other substances which may plug up the passages often protect larvae within the bark. It is believed that high temperatures increase the effectiveness of all of these chemicals.

The tests reported were designed specifically for elm bark beetle observations, and notes on other insects are presented for whatever interest they may contain.

OBSERVATIONS OF ELM TWIG-CROTCH FEEDING BY *Scolytus multistriatus* Marsh.

Philip P. Wallace

Following the hurricane of 1938 an outbreak of *Scolytus multistriatus* Marsh. occurred at Wharton Brook State Park, an area of approximately 20 acres, located in the township of Wallingford. In this area there were 144 elms with a D.B.H. of 2 or more inches, the diameter classes being distributed as follows:

2 to 4 inches	52
4 to 8 inches	32
8 to 12 inches	32
12 to 18 inches	20
18 to 30 inches	8

During the fall of 1939, with dead and dying elm material everywhere abundant, twig-crotch feeding by *S. multistriatus* was found to be quite general throughout the plot.

With the aid of a W.P.A. crew during the winter of 1939-40 a thorough cleanup of all dead and dying elm material within the park was accomplished. In addition, the Dutch elm disease eradication unit of the U. S. Bureau of Entomology and Plant Quarantine destroyed all elm material in which bark beetles were breeding or in which they might breed within one-fourth mile of the park.

In early May, 1940, five elm logs, 6 inches in diameter and 30 inches long, and heavily infested with *Scolytus multistriatus* larvae, were placed 100 yards west of the border of the park in order to determine the extent of attack within such an area when a known quantity of beetles was liberated from an outside point. Since the prevailing winds are westerly, there appeared to be a favorable opportunity for flight into the plot to the east.

The beetles emerged during June and July. In the fall a count of emergence holes in the logs showed that 2,025 *Scolytus multistriatus* adults had been liberated. A total of 10,075 elm twig crotches were then examined for bark beetle feeding scars. These were taken from 28 trees within the park, 5 to 35 feet above the ground, and located 301 to 675 feet from the point of beetle emergence. No evidence of beetle feeding was observed. On the basis of sample counts of twig crotches in trees of definite diameters the total elm twig crotches in the area is estimated to be 203,783. The sample thus represents 4.94 per cent of the total twig crotches taken from 19.4 per cent of the elms.

When the area was again examined in the fall of 1941 it was found that no elm material was present which could be considered attractive for bark beetle breeding and an examination of one-half the original number of twig-crotch samples revealed no signs of bark beetle feeding.

Observations reported earlier[1] have indicated that attack on elm twig crotches at various distances from the point of emergence follows a tendency wherein the attack is very severe close to the point of emergence, and theoretically approaches zero only at some unknown point which is the limit of beetle flight. It also appears that the normal limit of this distance of feeding is increased where very large emerging populations occur, and it may extend in some instances to a distance of several miles.

These investigations are of particular significance since it is well agreed that the principal means of transmission of the Dutch elm disease is through feeding of the elm bark beetle, *S. multistriatus*. It is demonstrated that under ordinary conditions of bark beetle abundance, and in the absence of any attractive breeding material, feeding by this beetle is practically eliminated in an area as small as 20 acres. Under these conditions it is probable that a 100 to 200 yard control zone offers considerable protection and this may also apply to much smaller areas.

THE EFFECT OF LOW TEMPERATURE UPON MORTALITY OF THE LARVAE OF *Scolytus multistriatus* Marsham

Philip P. Wallace and Raimon L. Beard

Extreme variations in the winter mortality of larval broods of *Scolytus multistriatus* Marsham suggest the consideration of low temperatures as a factor involved.

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[1] Wallace, Philip P., 1940. Conn. State Entomologist, Thirty-Ninth Report, Bul. **434**:297-298.

Observations made by Miller (8 and 9) and Beal (3) indicate that long periods of excessive cold are required to produce bark temperatures fatal to the larvae of *Dendroctonus brevicomis* under natural conditions. Hopkins (6) suggested that low temperatures had caused a heavy mortality in *D. frontalis*. High mortality from cold in the same species was later noted by Beal (2). The fact that the bark is not always as good an insulator as commonly believed, but that it does account for a considerable subcortical temperature lag was demonstrated by Graham (5) and Beal (1 and 3). Swaine (12) stated that the distribution of many bark beetles is limited by climate and host range, but he did not mention cold temperatures alone as being responsible for limiting the beetle distribution. Yuill (13) found that in California overwintering larvae of *Dendroctonus brevicomis* Lec. are killed by a temperature range of +5° to —7.5° F., and those of *D. monticolae* by a range of 15° to —12.5°. He further observed that prolonged exposures increase mortality in the upper critical range, but as the temperature is reduced the intensity of cold, rather than the length of exposure, becomes the governing factor.

A series of experiments has been conducted to estimate the importance of the intensity and quantity factors[1] of low temperature on mortality of *S. multistriatus* larvae. The normal habitat of the beetle larvae within the cortex first necessitates a consideration of the effect of this bark upon the environmental temperatures of the larvae. The intensity and quantity factors of cold could be modified by the insulating effect of the bark in one or both of two ways. In the first place, the rate of temperature change in the subcortical regions could be retarded, and in the second place, because of this temperature lag the subcortical regions might be prevented from reaching the extremes of air temperature.

The extent to which the bark does serve to insulate bark beetle larvae against extremely low temperatures was investigated during the 1939-40 season. During the summer of 1939 copper-constantin thermojunctions were inserted under the bark of living elm trees 6 inches in diameter. The bark over the thermojunctions was held tightly in place by tacks. In the late fall the trees were cut down and temperature records of logs were taken. Subsequent examination (see Figure 13) showed that normal callous formation had occurred and the thermocouples were actually embedded in the cambium region. Therefore true subcortical temperatures were registered.

Subcortical and air temperatures were compared under a variety of conditions. In one case, three logs containing thermojunctions were placed outdoors on the north side of a building. A thermojunction surrounded by an open glass tube placed near the logs served to register air temperatures. By means of a galvanometer the temperatures were noted at half hour intervals. In another case a log and an air thermojunction were placed in an insulated chamber containing a quantity of dry ice. This

[1] Terms as used by Payne (10).

provided a rapid drop from room temperature (about 70° F.) to —10° F. Temperature readings were made at 10-minute intervals. In another test, several continuous records of air and log temperatures were made.[1]

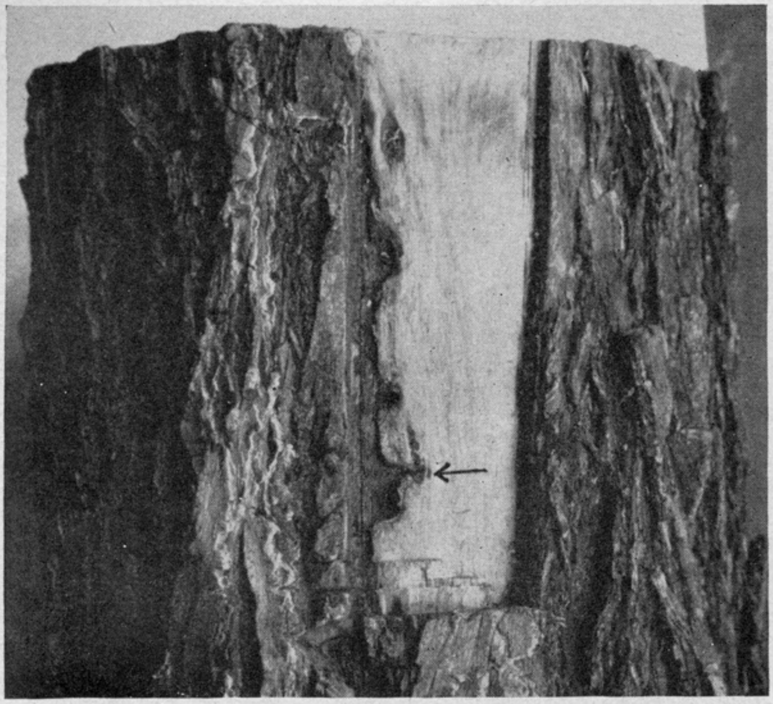

FIGURE 13. Elm log showing callous growth over the point where thermojunction was inserted.

All of these tests support general conclusions which were well illustrated (Figure 14) by a single continuous 24-hour record of log and air temperatures made on February 26-27, 1940. The day was clear, and although

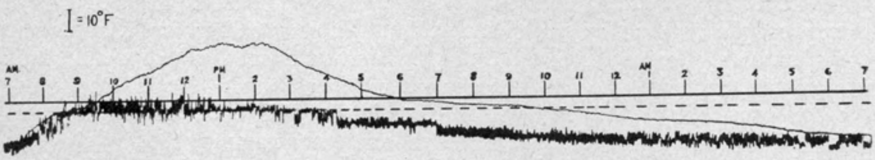

FIGURE 14. A 24-hour continuous record of air (jagged line) and log (smoother line) temperatures.

the log was in the sun until 3:10 P. M., the side containing the thermojunction was directed away from the sun. In the illustration (Figure 14)

[1] The writers are indebted for these records to Dr. Raymond H. Wallace, of the University of Connecticut, whose duplex recording galvanometer was used.

the air temperature is represented by the lower, very irregular line, the reference point (32° F.) being indicated by the horizontal broken line. The log temperature is represented by the upper, smoother curve, and its reference point (32° F.) is indicated by the horizontal continuous line. At 7 A. M., when the air temperature registered about 16° F., the subcortical temperature coincided with the air temperature within two or three degrees. During the forenoon the air temperature rose rapidly, closely followed by the subcortical temperature without an appreciable lag. By 10 o'clock the air temperature reached a more or less uniform level, but the log temperature, because of heat absorption, continued to rise until it was as much as 27° F. higher than the air temperature.

This is in close agreement with the investigations of Graham (5). In the afternoon as the exposure to the sun decreased, the log temperature initially declined more rapidly than did the air temperature. With the approach of evening, however, the rates of decline were more nearly parallel. The significant point in the record during the night is the lag of the subcortical temperature behind the air temperature. It was not until 4 or 5 A. M., February 27, that the log temperature reached the air temperature. It is therefore evident that although there may be a temperature lag of several hours, it does not insure the log temperature against reaching the minimum air temperature.

For the conditions under which these tests were made, certain conclusions may be drawn: (A) The bark insulates the beetle larvae against the very rapid, momentary, changes which characterize air temperatures. (B) With a gradual change in air temperatures, the subcortical temperature follows the change with a lag varying in time up to several hours. (C) The insulation effect of the bark does not prevent the subcortical temperatures from reaching the extremes of the air temperatures. (D) During daylight, even when away from the sun, the log temperature is higher than the air temperature. Hence, although the entire log may not vary so much, it is subject to much greater extremes than the air temperature.

Freezing Point

The freezing point of larvae of *S. multistriatus* was determined by the thermocouple method of Robinson (11). It is well known that as the environmental temperature falls, the temperature of the insect also falls until a point, termed the undercooling point, is reached. Then, due to the heat of crystallization attending the freezing of the body fluids, the temperature rises to a point termed the rebound point, and then falls again. In determinations made on 25 larvae of *S. multistriatus*, the undercooling point ranged from +2.5° to —13.0° F., with a mean of —8.0° ± .5° F. The mean rebound point was +10.4 ± .5° F. Although the undercooling point of many insects is the temperature below which they cannot survive, this is not true of the species in question, for many of the larvae are apparently uninjured by the freezing of their free body fluids.

Rate of Temperature Fall

In order to determine if the rate of temperature drop affected the freezing point, larvae were subjected to falling temperatures at various rates ranging from a drop of 29° F. in 1½ minutes to a drop of 40° F. in 3 hours and 35 minutes. Although a limited number of larvae (i.e., 35) were so tested, differences in freezing points were no greater than could be accounted for by individual differences and so could not be correlated with the rate of temperature drop.[1]

Cyclic Exposure Effects

The mortality attributable to cyclic exposures of larvae was determined by using a group of 100 individual larvae in each of two tests. The thermoregulator of the freezing unit was so adjusted that the cooling unit turned on when the temperature of the chamber reached —2° F., and turned off when the temperature dropped to —18°. Thus the temperature varied from —2° to —18° F. in a cyclic manner, the alternation occurring from three to four times during a 24-hour period. One group of 100 larvae was thus subjected for a 24-hour period, and another group of 100 for three days. The resulting mortality was 57 per cent and 56 per cent, respectively, indicating that within these limits recurring high and low temperatures effect no greater mortality than that resulting from one momentary exposure to the minimum temperature of the treatments. See Figure 15A.

In view of the facts demonstrated that: (A) the temperature lag does not insure the subcortical temperature against reaching the minimum air temperature; (B) the rate of temperature drop as tested affects little if any the freezing point of the beetle larva; (C) normal development of larvae is not necessarily prevented by freezing of the body fluids, and (D) cyclic temperature changes within the limits mentioned do not increase larval mortality, it may be concluded that the insulating effect of the bark is of negligible importance in the mortality of larvae due to low temperatures.

Effect of Momentary Exposure to Cold

The effect of momentary exposure to cold was tested during two seasons. Larvae were subjected to minimum temperatures of from 0° to —70° F. at intervals of 2 degrees. The exposure was made by placing the larvae in a container which in turn was placed in a Dewar flask containing dry ice and alcohol. The temperature was noted by the use of a galvanometer to which leads were connected from a thermocouple in contact with the larvae. When the temperature of the larvae reached the desired point, the larvae were removed from the cooling chamber and allowed to warm up to room temperature, after which they were placed in the constant temperature cabinet.

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[1] Luyet and Galos (7), working with minute portions of plant tissue, found a slight rise in the cooling point resulting from a very slow cooling velocity.

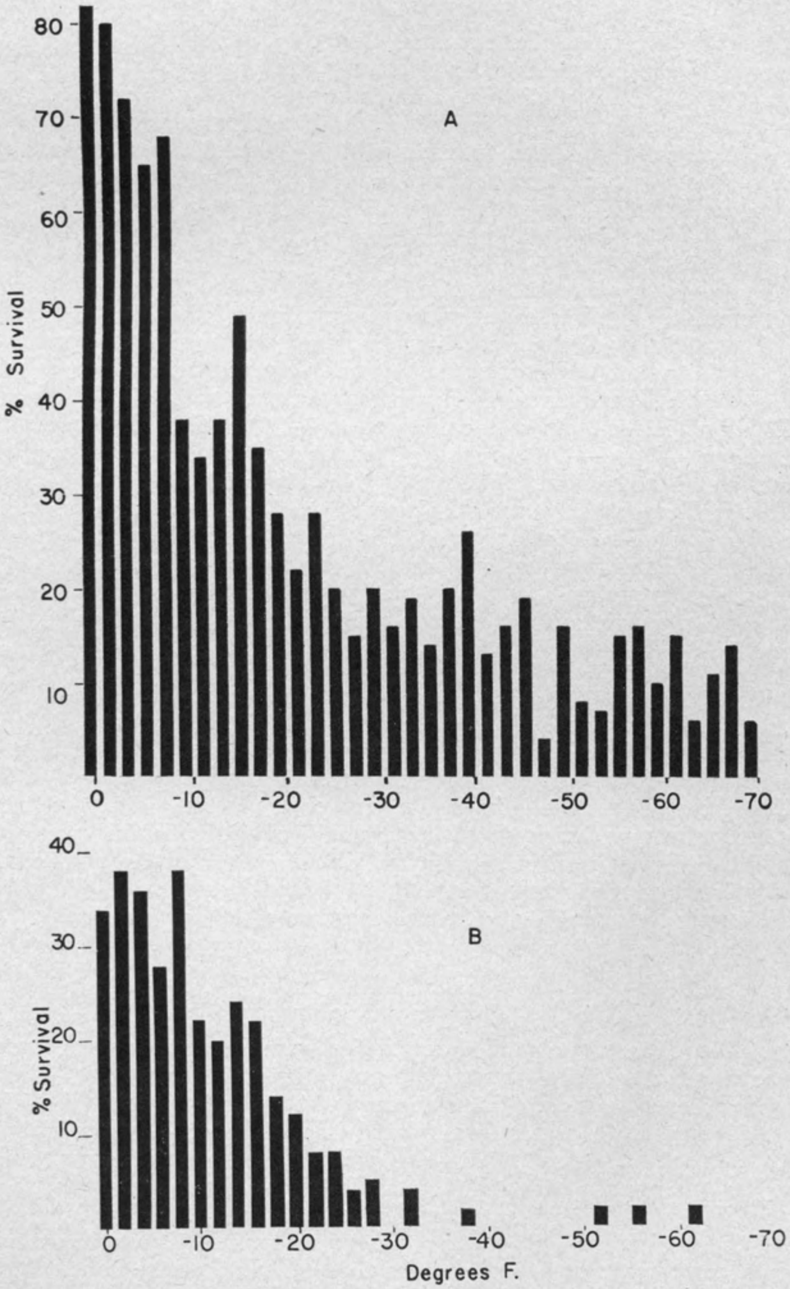

FIGURE 15. A. Graphic representation of survival of *Scolytus multistriatus* larvae as determined by tactile response after momentary cold temperature exposures, 1940 and 1941. B. Survival as determined by ecdysis, 1941 only.

During 1940 two groups of 25 larvae each were exposed to each temperature. The larvae were taken indiscriminately as to size and age from second-generation galleries from one log. Since the time involved in each exposure was of the same order of magnitude, the rate of fall in temperature is not a factor which needs be considered in the interpretation of results, particularly since it was earlier shown to be of negligible importance. The larvae were retained for several days after treatment, and the mortality was noted. The criterion for life, in the absence of spontaneous movement, was a vigorous response to mechanical stimulation. Since at times a larva, even though alive, fails to give such response, periodical observations were made to insure all larvae being properly identified as living or dead. A tabulation and discussion of the data obtained will be considered below, but the most striking result is that even at the extremely low temperature of —70° F. mortality was not complete.

These data failed to demonstrate clearly a critical zone of cold below which most of the larvae were killed and above which most of them survived. Moreover, no minimum temperature was reached at which all larvae died.

In 1941 these tests were repeated. Since several larval instars of *S. multistriatus* are commonly present during the winter, and earlier tests had demonstrated that very small larvae and those with food in the alimentary tract are particularly susceptible to cold, these classes were excluded. No attempt was made to determine the instars but it was found that the use of those larvae whose head widths measured .54 to .81 of a millimeter yielded larvae of uniform size composed chiefly of the final and penultimate instars. Five groups of 10 larvae each were exposed to each temperature. After these exposures the larvae were retained until they either underwent ecdysis into the next larval stage, or into the pupal stage, or died. Such manifestation of growth as moulting or pupation supplied significant evidence that life processes were not significantly affected by cold treatment. Extensive trials have demonstrated that, although the tactile response and general appearance of larvae have been widely accepted as satisfactory criteria of unimpaired life activities after exposure to cold, the larvae of this species at least must be retained for a considerable time before the living condition of the larvae can be accurately determined.

The bar graphs in Figure 15 represent a summary of these data and concern the treatment of a total of 3,600 larvae. The mean survival of the larvae in both tests as determined by the method previously described, namely, response to tactile stimulation, is represented by the height of the bars in chart A. The percentage of larvae surviving to moult or pupate in 1941 tests is represented by the height of the bars in chart B.

A tendency for the larval mortality to increase with a decrease in temperature is obvious. The regression is clearly not rectilinear, nor do the data conform to an hyperbolic curve. Although the measure of variation is somewhat above the 5 per cent level, these data are strongly suggestive of a log-probit trend and for practical purposes of comparison have been shown to follow this characteristic more closely than any other relation. Moreover, the effect of cold, in addition to killing many larvae, is to weaken others so that even if they do manifest life for some time, they fail to moult or pupate. It is of particular interest to note that one larva was alive and active seven days after exposure to —70° F. and two larvae pupated after exposure to —62° F.

Effects of Quantity and Intensity of Cold

The first tests of the effect of prolonged exposure to cold on the mortality of *S. multistriatus* larvae were carried out with naturally infested elm logs which were brought in from the field and placed in compartments maintained at constant temperatures of 32° F., 10° F. and —5° F. for various lengths of time. The results obtained clearly indicated that under the conditions of the experiment no direct correlation existed between mortality and the temperatures to which these larvae were exposed. Moreover, no correlation was observed between the duration of exposure and the larval mortality. It is probable that some effects of parasitism and predation obscured the discrete effect of cold temperature in spite of the fact that in determining the mortality, larvae were excluded which unquestionably had died from causes other than cold. The important fact became evident, however, that many larvae of *S. multistriatus* survived exposure for more than two months at a temperature of —5° F.

Further trials in which elm logs containing larvae, infested under controlled conditions, were exposed to 0° F. and —15° F. for various lengths of time indicated that at a temperature of 0° F. there is no correlation between mortality and the quantity factor of cold. As indicated in Table 38, there does appear to be a trend toward increased mortality with increased length of exposure at —15° F.

Table 38. Time-Mortality Tests, 1939

Exposure to 0° F.			Exposure to -15° F.		
Time of exposure	Total no. of larvae	Per cent mortality	Time of exposure	Total no. of larvae	Per cent mortality
4 days	239	35.8	2 days	376	34.3
8 days	287	36.0	4 days	333	60.1
16 days	27	58.8	8 days	380	77.6
32 days	107	24.4	16 days	506	84.0

Since the rapidity of temperature drop was shown to be of little consequence in the mortality of these larvae, and the insulating effect of the bark is of short duration, it was considered that comparable results of greater precision could be obtained by using larvae removed from the bark. It was also hoped that a more definite mortality trend might be evident if large numbers of uniform larvae were exposed to a lower range of temperatures for regular time intervals.

Larvae were removed in December and January from infested logs stored at a refrigerating plant at 32° F. They were selected in the same manner as described for the momentary exposures.

Each larva was placed on cotton in an individual vial stoppered with a cotton plug. Groups of vials were set on a rack in the freezing compartment, which was a refrigerator of the ice-cream storage type controlled by an adjustable thermoregulator. The minimum temperature attainable was —23° F., with the fluctuation at any given temperature being no greater than three degrees. The accuracy of the thermoregulator was checked periodically by a thermocouple suspended in the freezing chamber and connected to a galvanometer.

For the periods of one, three, five and seven hours, groups of 50 individual larvae were exposed to —8°, —13°, —18° and —23° F. For longer periods of from one to seven days, 100 larvae were used for each exposure at these same temperatures. Following exposure, all larvae were kept in a cabinet maintained at a constant temperature of 80° F. and at moderate humidity. Using the same criteria of tactile response for survival as described above, the larvae were examined at intervals. Because it was found that after a few days many larvae died, it was necessary to determine if any appreciable mortality in addition to that caused by cold resulted from the retention of larvae in the constant temperature (80° F.) cabinet. Accordingly, eight groups of 25 larvae each, not exposed to cold, were kept under these conditions. The average mortality of these groups after three days was 0.5 per cent and after seven days, 2.0 per cent. These low figures minimize the possibility that much of the mortality attributed to cold was actually due to the maintenance of larvae outside their natural environment.[1]

A summary of the larval mortality resulting from the cold exposures indicated above, made during 1941, is given in Table 39. The conclusion

TABLE 39. *S. multistriatus*, MORTALITY DUE TO COLD EXPOSURES, 1940

Time of exposure	Temperature degrees Fahrenheit -8	-13	-18	-23
Momentary	32	62	66	72
1 hour	16	20	48	100
3 hours	10	50	48	100
5 hours	12	52	62	98
7 hours	10	24	62	96
1 day	62	63	84	100
2 days	74	69	89	97
3 days	61	83	87	100
4 days	63	76	77	98
5 days	59	55	99	95
6 days	60	56	86	100
7 days	78	55	93	90

[1] Outside the bark and hence subject to lack of food and modified moisture conditions.

at once apparent from these data is that the intensity factor of cold definitely affects mortality. From —8° to —23° F. an increased mortality is readily evident and is supported by statistical analysis which shows the differences to be very highly significant. The influence of the length of exposure at a given temperature is not clear, and the data do not bear out the 1939 data which seemed to indicate an increased mortality with a longer exposure time at a temperature of —15°. Since the larvae used in 1939 were less uniform than those used in 1940, the latter data should be more reliable.

To more clearly establish the effect of prolonged exposure to cold or its interaction with cold intensity, further tests were carried out in 1941-42. Larvae were selected in the manner previously described but were retained after treatment until they had moulted, pupated or died. This gives a precise criterion for life or death not equaled by tactile response which for this species is unreliable.

Exposures were arranged in the geometric series of one, two, four, eight, 16, 32, 64, 128 and 256 hours. Since it was possible to reach —30° F. with this refrigerator, exposures were begun at that temperature for the various time periods and raised at five degree intervals up to 0° F. For each exposure 100 larvae were placed in individual surface depressions in paraffin which had been poured into a petri dish, as described by Yuill (13). This method of handling the material is considered very satisfactory. Thus there were 63 treatments and seven control groups, employing a total of 7,000 larvae. Since it was found that from 30 to 60 minutes were required for the temperature of the larvae to reach that of the freezing compartment, they were placed in the compartment for the necessary length of time before the period of exposure was considered to commence.

The results of these tests are presented in Table 40.

TABLE 40. 1942 COLD EXPOSURE TESTS—PER CENT MORTALITY

Time of exposure (in hours)	Temperature degrees Fahrenheit						
	-30	-25	-20	-15	-10	-5	0
— (Control)	9.0	7.0	20.0	7.0	38.0	9.0	22.0
1	100	100	87.5	69.9	49.3	15.6	15.0[1]
2	100	100	92.5	87.1	73.0	17.8	15.0
4	100	100	97.5	74.2	54.9	2.3	12.0
8	100	100	95.0	88.2	64.3	4.8	29.0
16	100	100	87.5	79.6	88.7	5.6	10.0
32	100	100	98.75	91.4	61.2	36.0	23.0
64	100	100	93.75	90.3	89.5	10.1	12.0
128	100	100	97.5	94.6	81.3	7.8	8.0
256	100	100	97.5	96.8	99.2	17.6	52.0

[1] Mortality figures for 0° F. not based on survival of control inasmuch as mortality for the control exceeded that for most of the treatments.

These data represent percentage kill calculated on the basis of those which survived in the corresponding control.

The criterion for death was the failure of the larvae to develop. Although none of those exposed for an hour or more to —25° and —30° F. moulted or pupated, a considerable number were active and lived for several days after exposure.

In these tests a temperature zone is apparent below which a significant mortality occurs and above which mortality does not depart significantly from that of the control groups. This point is clarified by the character of the graphs in Figure 16. The duration periods of one, 16 and 256

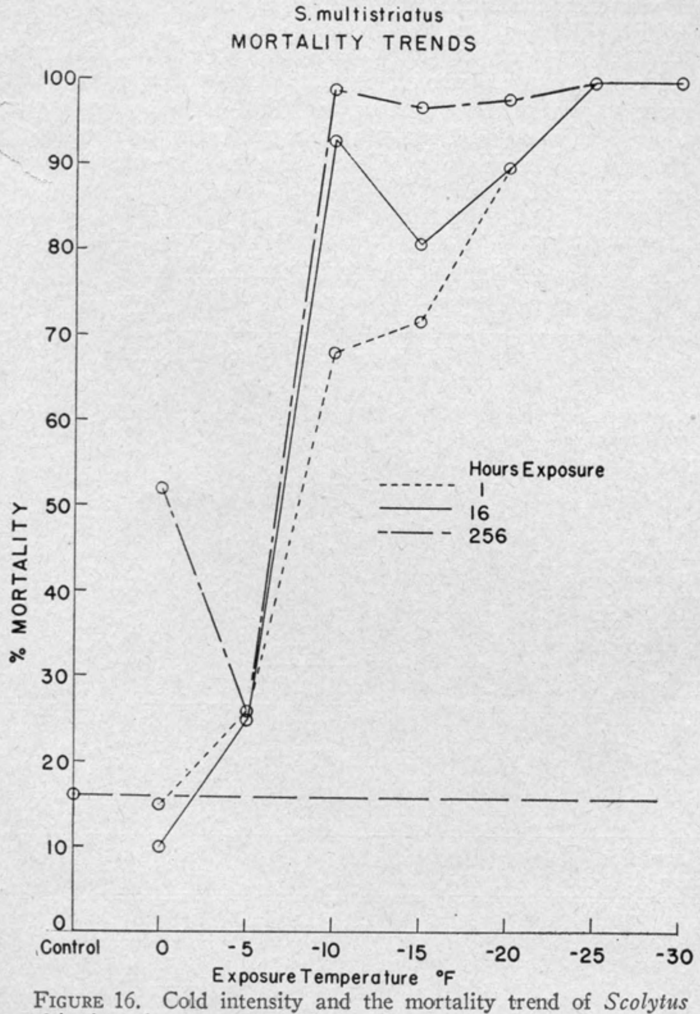

FIGURE 16. Cold intensity and the mortality trend of *Scolytus multistriatus* larvae.

hours were chosen arbitrarily, and mortality is plotted against the exposure temperatures. No completely satisfactory method for correcting the mortalities occurring at 0° F., relative to the control, was found, and all points plotted on this figure represent the actual number of individuals which died for each treatment. It is interesting to note that in analysis there is no significant departure of the mortality at 0° and —5° F. from that of the controls. An abrupt rise in the slope of the line at the same temperature in each instance graphically indicates the zone where the effect of cold intensity is discernible. This occurs for every duration between —5° and —10° F. Since the average undercooling point of the body fluids of the larvae, —8°, falls within this zone, it is suggested that the range within which cold intensity can be observed to kill these larvae is closely associated with their undercooling point.

Since in the data derived from tests of the effects of quantity and intensity of cold there appeared from inspection to be no significant difference among mortalities occurring at 0°, —5° F., and the controls, these data have been divided into two groups, each analyzed in the same manner (Bliss, 4). In this way it is possible to more satisfactorily segregate the experimental error.

TABLE 41. ANALYSIS OF VARIANCE FOR THE DATA DERIVED FROM TESTS OF COLD INTENSITY AND DURATION OF COLD

Variance	Degrees of freedom	Sum of squares	Mean square	Variance ratio F.
	A. Temperatures -10°, -15°, -20°			
Between temperatures	2	3.52	1.76	10.185[1]
Trend on time	1	3.6097	3.6097	20.89[1]
Remainder between time	7	.7193	.1027	.594
Temperature by time	2	.5623	.2811	1.627
Remaining interaction	14	2.4187	.1728	1.
Total	26	10.83		
	B. Temperatures -5°, 0° F.			
Between temperatures	1	.3386	.3386	1.935
Trend on time	1	.1786	.1786	1.020
Remainder between time	7	2.2714	.3244	1.854
Temperature by time	1	.0185	.0185	.1057
Remaining interaction	7	1.223	.175	1.
Total	17	4.03		

[1] Highly significant.

TABLE 42. STANDARD DEVIATION OF ITEMS FROM THEIR MEANS AND REGRESSION COEFFICIENTS

	0°	-5°	-10°	-15°	-20°
Standard deviation	.456	.494	.758	.434	.386
Regression coefficient			.7054	.4546	.2514

Within the range of —10° to —20° F. there is a rectilinear log probit relation between cold intensity and mortality. There is a similar relation for duration of cold and mortality, and the differences in both cases are shown to be highly significant. Outside of these temperature limits there is no indication, for the treatments under consideration, of any recognized trend.

As presented graphically in Figure 17, the slope of the line expressing the rate of increase in mortality per unit of time is flatter at the colder temperatures. However, on analysis this difference is not shown to be significant. Although in graphic presentation there is an appreciable scatter of points away from a straight-line relationship for time-mortality at —10° and at —20°, the mean square for error term in the analysis demonstrates that these deviations are not significant. At —5° and 0° F. the deviations are shown to be too great to follow this trend.

It is apparent that the range is narrow between the temperature zone where there is no appreciable mortality from cold and where mortality is complete.[1] The variability of response within each test and the apparent

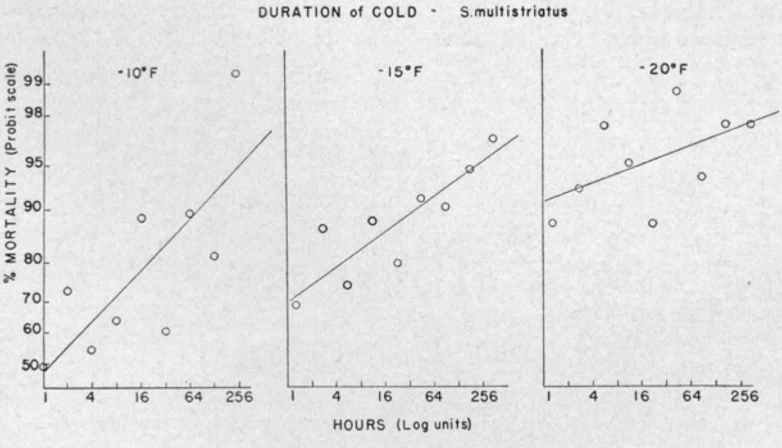

FIGURE 17. Duration of cold and mortality of *Scolytus multistriatus* larvae in log-probit units, at —10°, —15°, and —20° F.

lack of agreement between certain tests, particularly when the response in the momentary exposure test is compared with that in subsequent tests on prolonged exposure, can be attributed chiefly to individual variation among the larvae tested. Although every effort was made to assure larvae of uniform size, age, and habitat, these could not be rigidly controlled. In spite of the variability of response, however, the principal trends seem obvious.

The subject of cold hardiness of this species has not been considered, but it is assumed that all larvae used in this experiment were cold hardy. They were in a winter condition and were maintained at a relatively low temperature until the time of use.

[1] Except for isolated individuals which are able to withstand great extremes of cold, such as the two mentioned earlier which pupated after momentary exposure to -62° F.

The climate of Connecticut, as well as the rest of New England, is subject to rapid changes and great local variation. In the central and northern part of the State minimum temperatures of —15° to —20° F. are not rare, while a temperature of —10° F. seldom occurs along the coast. Since such extremes are usually of short duration and the hibernating places may be protected by snow or debris, those larvae are seldom actually exposed to lethal temperatures. No appreciable mortality of *Scolytus multistriatus* larvae due to cold weather has been noted during the past eight years of observation in Connecticut.

Summary

A. Bark insulates the larvae of *Scolytus multistriatus* against the very rapid, momentary changes which characterize air temperatures.

B. With a gradual change in air temperature, the subcortical temperature follows the change with a lag varying up to several hours.

C. The insulation effect of bark does not prevent the subcortical temperature from reaching the extremes of air temperature.

D. The larvae of this species are not necessarily killed by the freezing of their body fluids on reaching the undercooling point, and the rate of temperature drop apparently does not affect the freezing point.

E. The insulating effect of bark is of negligible importance in reducing the mortality of these larvae due to cold temperatures.

F. Small larvae and those with food in the alimentary tract are particularly susceptible to cold.

G. Cyclic temperature changes as tested effect no greater mortality than that resulting from one exposure to the minimum temperature of the treatment.

H. No minimum temperature was reached at which all larvae died when momentarily exposed. Two larvae momentarily exposed to —62° F. pupated and reached the normal adult stage, and one was alive and active seven days after exposure to —70° F.

I. The relation between the intensity factor of cold and larval mortality, and between the quantity factor and mortality may both be expressed graphically as a straight line on the log-probit scale.

J. A temperature range is demonstrated, above which the effect of intensity of cold on larval mortality is not discernible and below which a significant increase in mortality occurs. This zone is between —5° and —10° F.

K. Cold temperatures in Connecticut are seldom so extreme or extended that they may be expected to effect an appreciable mortality of the larvae and limit the distribution of *Scolytus multistriatus* Marsh.

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MISCELLANEOUS INSECT NOTES

A Scale Insect on Phlox. Specimens of perennial phlox were sent to this office from East Haven on June 5. The stems were distorted with a slightly sunken area near the base of the distortions. In each of these sunken areas was a soft, flat scale insect of a greenish color and nearly transparent. The stems were kept moist until the end of June. The scales developed until they were about two-thirds grown and appeared to be a species of *Asterolecanium* (Figure 18, left).

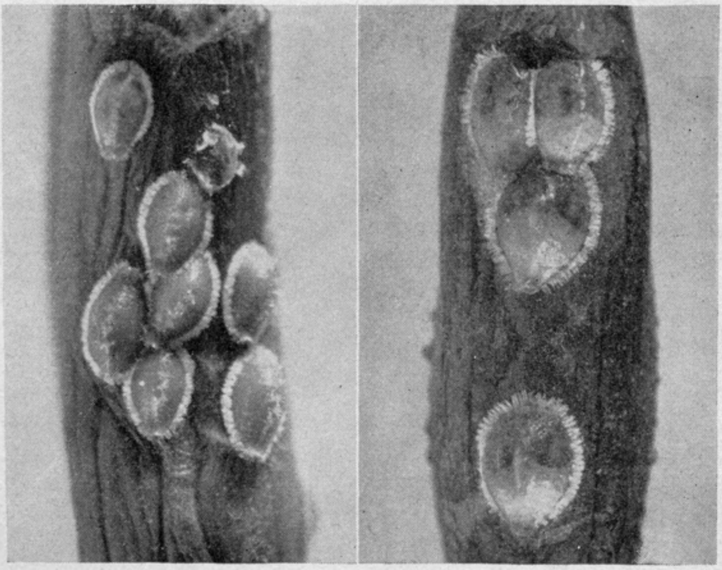

Figure 18. *Asterolecanium arabidis* on perennial phlox. Left, young scales photographed in June. Right, mature scales. Both × 6.

On August 12, phlox stems with mature scales were received from a garden in New Haven. These were identified as *Asterolecanium arabidis* Sign. from a recent monograph on *Asterolecanium*.[1] Miss Russell, the author, gives six records from the eastern United States of *A. arabidis* with three different species of phlox as host plants.

The late Dr. Britton collected *Asterolecanium arabidis* on *Lechea* sp., a native herb, at Mount Carmel, Conn., in 1925, and Miss Russell also lists this species from a number of unrelated host plants including privet, garden sage, red clover, flax, Weigela and ash.

During the last half of August the young scales were emerging, and as the phlox stems die to the ground in the fall it would indicate that the young scales may pass the winter on the roots of the plants, migrating to the new growth in the spring. No tests were made to control this insect. The mature scale insects are shown on Figure 18, right. [B. H. WALDEN]

The Bronze Cutworm, *Nephelodes emmedonia* var. *violans* Guénée. As considerable turf damage had been caused by this insect in the esplanades and bordering turf areas along the Merritt Parkway in four towns in Fairfield County in the spring of 1941, the area was visited on May 22, 1942, to determine the extent and severity of the infestation. The continuous area of infestation was confined to the towns of Greenwich, New Canaan, Norwalk and Stamford, as in 1941, but with isolated infestations in Trumbull and Westport. Another infestation was reported by the Landscape Division of the State Highway Department as occurring in Meriden, where the insect was feeding in the esplanade of the Wilbur Cross Highway.

The cutworm population was much less than that occurring in 1941, and the feeding was less severe. Numerous dead worms killed by a wilt disease were observed in all the areas examined and most of the larvae collected were later found to be infected. Practically all the grass areas recovered by fall, and very little evidence of feeding remained.

[J. PETER JOHNSON]

A Scarabaeid, *Aphonus castaneus* Melsh. On September 30, 1942, a number of larvae were brought in by Mr. Schread of this office, who had obtained them from turf in a golf course located in the town of Orange. Mr. Schread reported that the turf was severely damaged on one fairway and that he found as many as 83 grubs to a square foot. These grubs

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[1] Russell, Louise M., 1941. A classification of the scale insect genus, *Asterolecanium*. U.S.D.A. Misc. Publ. No. **424**:44-47.

were found to conform to Sim's[1] description of *Aphonus castaneus*, and this was later verified by Dr. Adam Böving from material sent to the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, Washington, D. C.

On October 9, a total of 2,600 grubs were obtained from an area of 120 square feet in the rough bordering the main infestation in the fairway. This gave an average of 21.6 grubs to a square foot. A survey of the golf course indicated that an area of approximately five acres was generally infested on two adjoining fairways, with small isolated infestations on other fairways. The damage to the turf at this time was much more evident than during the last week of September. Evidence of skunk feeding was observed in all the areas of infestation, being very heavy in the large area, while small individual holes were present in the turf in the lighter and isolated infestations.

Four other infestations, totalling approximately 12 acres in extent, were found later in the season, one on a golf course in Wallingford where turf was damaged, one in Bloomfield and two in Hartford. The infestations in Bloomfield and Hartford were found in areas where Japanese beetle grubs predominated.

Diggings were made in the Wallingford Golf Course on October 24 and the majority of the *A. castaneus* larvae were in the upper inch of soil. Twenty-two grubs were found about three-quarters of an inch below the surface in an area less than 0.25 square feet, and six of these were infected with a mummifying muscardine fungus. While making diggings during the first week in November, it was noted that the majority of the grubs were from 2 to 4 inches down, apparently moving to hibernating depths.

[J. Peter Johnson]

Notes on May Beetles. Information concerning damage to turf in numerous Connecticut towns caused by second-year *Phyllophaga* grubs or larvae in 1941 was published in the Forty-First Report of the State Entomologist, Bul. **461**, pp. 524-526, July, 1942. Diggings were made on August 17 and 27, 1942, in Pine Orchard and Avon, in turf areas damaged in 1941 by the grubs or larvae of *P. fusca* and *P. hirticula* to determine their stage of development. Most of the insects found were in the pupal stage or newly formed adults. This would indicate that a flight of adult May beetles of the two species may be expected in the spring of 1943 in the areas where turf damage occurred in 1941. [J. Peter Johnson]

Lilacs Injured by the European Giant Hornet. During September, girdled stems of lilac were received from East Windsor, Hartford and

[1] Sim, R. J., 1934. U.S.D.A. Circ. **334**:9, 16, 19.

Meriden. This injury, shown in Figure 19, was caused by the European giant hornet, *Vespa crabro* Linn., gnawing the bark to obtain the fibers to use in constructing its nest which is often built in a hollow tree. Various

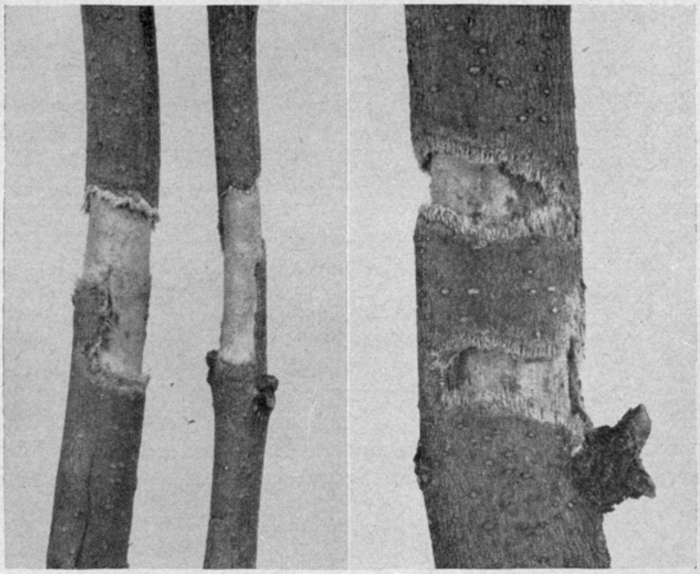

FIGURE 19. Lilac stems girdled by the giant European hornet.

shrubs and trees, including lilac, willow and poplar, have been observed with gnawed branches. In 1920 this insect was found gnawing the large stems of dahlias growing near woodland.

The European giant hornet was introduced into this country many years ago, and was first found in Connecticut at New Haven during 1900.

This insect is considered a pest only when it occasionally attacks cultivated plants. If the nest can be located, the insect can be controlled by destroying the colony. It has been suggested that a spray of bordeaux mixture and lead arsenate will repel or possibly kill the hornets.

[B. H. WALDEN]

The Imported Long-Horned Weevil, *Calomycterus setarius* Roelofs. Several specimens of this insect were received for identification from Groton and one from New Haven during the summer. In both cases these were the first weevils reported from those towns, and it is now known that the weevil is present in 14 widely separated towns of the State. From observations made in July and August in several of the older infested areas, it was noted that the weevils though prevalent were not as numerous as in 1941. In New Milford the adults were feeding on English ivy, white clover and lawn grass, and in Sharon on alfalfa, Swiss chard, red clover, white clover, corn, Cobbler potatoes, phlox, rose, violet and weeds.

While the observations were being made in the town of Sharon, a request was made to visit an estate just over the line in the town of Amenia in New York State. The weevils were very numerous at this site, and asters, hollyhocks, marigolds and a Dorothy Perkins rose were severely defoliated. Lawn grass, English ivy, coleus, geranium and shrimp plant were among the host plants, while a nearby field of corn showed no evidence of weevil feeding.

Adults were again troublesome because of their habit of invading dwellings and buildings. Homes and other buildings in Lakeville, New Milford and Sharon were invaded. An occupant of one building spread borax powder on the window ledges and a number of dead weevils were observed on the inside of the window sills. The weevils were said to be less troublesome after the borax powder was used. [J. Peter Johnson]

Winter Mortality of the European Pine Shoot Moth. Cold temperatures of —15° F. commonly occurred in Connecticut during January, 1942, with the exception of areas bordering Long Island Sound and Fairfield County. Previous to January 11 occasional observations indicated a normal winter mortality of European pine shoot moth (*Rhyacionia buoliana* Schiff.) larvae from various causes of between 10 and 50 per cent. Since it is known that exposure of these larvae to about —15° F. for a period of time long enough to insure the body temperature of the larvae reaching the air temperature is fatal to a majority of them, sample collections of infested tips were taken from various red pine plantations to estimate the extent of mortality from extreme cold. Fifty tips per plot taken from 10 trees was considered a satisfactory sample for these purposes. In certain cases small samples constituted all the infested tips that could be found in the plantation. At the time of the extreme cold there was too little snow present in any part of the State to afford any protection to the larvae.

Minimum temperature reports from various towns in Connecticut are listed below. An effort was made to check the thermometers used, and there is assurance that most of them are correct in the low range within ±1 degree and all are correct within ±2 degrees F. These records were generally taken quite close to the sampled plantations.

Hamden	—15° F.	Southington	—16° F.
Hamden	—14°	New Haven	—12°
Cheshire	—15°	Cornwall	—15°
Cheshire	—15°	Winchester	—12°
Wallingford	—14°	Hartford	—10°
North Haven	—14°		

Samplings, by towns, for European pine shoot moth larval mortality are shown in Table 43. The column "total mortality" is based on the percentage of live larvae found in the total infested tips collected. The "mortality from severe cold" was determined by the appearance of the larvae found. This figure represents the percentage of total larvae found in a turgid condition but which were dead, and closely approximates the actual percentage of the total larvae which were alive before January 11 but died from the effects of extreme cold.

TABLE 43. WINTER MORTALITY OF THE EUROPEAN PINE SHOOT MOTH

Town	Tips collected	Total dead larvae in turgid condition	Per cent mortality from severe cold	Total winter mortality
Cornwall	100	89	46	52
Cornwall	50	34	47	64
Washington	25	9	45	80
Winchester	110	108	63	64
Tolland	25	20	50	60
Tolland	4	2	100	100
Vernon	9	4	100	100
Avon	25	17	24	48
West Hartford	25	13	23	60
Farmington	25	15	40	64
Portland	24	15	73	83
Woodbury	40	15	55	83
Middlebury	100	100	96 (?)	96
North Haven	100	59	92	95
Wallingford	50	46	96	96
Wallingford	110	64	91	95
Southington	126	76	93	96
Fairfield	40	14	7	68
Westport	50	21	62	84
Weston	50	14	28	80
Trumbull	50	28	40	66
Ashford	9	5	80	89
Ashford	4	4	100	100
Pomfret	15	13	45	53
Hampton	76	43	18	54

A wide variation in larval mortality is evident in localities where the same intensity of cold was recorded, but a high mortality of European pine shoot moth larvae certainly occurred during the winter of 1942 in some sections of the State.

[PHILIP P. WALLACE]

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[1] Inasmuch as the articles in this Report written by members of the Department all bear the authors' names, they are not listed here.

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