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CONNECTICUT STATE ENTOMOLOGIST

FORTY-FOURTH REPORT

1944

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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-fourth report of the State Entomologist for the year ending October 31, 1944.

Respectfully submitted,

ROGER B. FRIEND,
State and Station Entomologist

CONTENTS

CONTENTS—Continued

CONTENTS—Continued

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R. B. FRIEND

WORK OF THE DEPARTMENT

The activities of the Department during the past year have covered several phases of research and control operations in relation to insect pests. These involve the protection of agricultural crops and shade and forest trees against injurious species, and the control of pests directly affecting man, such as those found in households and those attacking man outdoors. As a preliminary step in the development of practical control methods applicable in the field, it has been necessary to study the biology of certain species, the general principles of insect toxicology, and the relation of insect attack to the health and vigor of plants. Certain direct control operations, as the inspection of nurseries and apiaries, the control of the gypsy moth and the Dutch elm disease, and the necessary work in connection with plant quarantine enforcement have also been carried out. In addition to this, the Department is involved, to a certain extent, in rodent and mosquito control operations. In many phases of its work, the Department cooperates with the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture.

Investigations

In the control of orchard pests, one of the important factors is the adhesion of insecticides to the foliage and fruit. In other words, so-called "stickers" play an important role. By employing suitable "stickers" in the spray mixture so that the insecticide adheres well, the number of applications of spray materials can be reduced without unduly affecting the control of certain pests of apples. This applies particularly to sprays containing lead arsenate and is of great practical importance in the economic production of fruit. In such a reduced schedule the concentration of lead arsenate in the spray mixture must be increased, and the fungicide used must be compatible with the other ingredients. Satisfactory control of scab, European red mite, curculio and apple maggot has been obtained. The problem of a toxic residue of arsenic on the apples at harvest is not acute. The results of these investigations have been published in Station Bulletin 485.

The insecticide known as DDT [2, 2-bis (parachlorophenyl) 1, 1, 1-trichloroethane] has shown promise in controlling the oriental fruit moth on peaches and quinces and the apple maggot on apples in laboratory and field experiments. Satisfactory control of the peach tree borer infesting nursery trees has been obtained by applying a low concentration of DDT to the bases of the trees in June.

The plum curculio is a serious pest of fruit in Connecticut and its control is frequently a problem. The activity of the curculios and hence the damage to apples may be correlated with mean temperatures above 70° F. in the spring following the petal fall period (page 339).

The European apple sawfly has recently been found in several apple orchards near the shore. The larvae bore into the fruit in a quite characteristic manner. The future status of the sawfly as an apple pest is yet to be determined, but its control may not offer any serious difficulties (page 341).

The utilization of parasites and diseases for the control of insect pests has been given considerable attention for several years. The propagation and liberation of *Macrocentrus ancylivorus* for control of the oriental fruit moth in peach orchards was carried out in 1944 as in previous years (page 330). The Connecticut Pomological Society cooperates actively in this program. Three insect parasites and one bacterial parasite of the Japanese beetle have been widely distributed in the State and their progress watched (page 331). The incidence of "milky" disease of grubs, caused by the bacterium, is increasing in many areas. The "milky" disease organism has been studied in the laboratory with the aim of gaining a better knowledge of the mode of infection, the spore dosage required to cause disease, the pathogenicity of the bacterium to the grub, the transmission of the disease, and the factors affecting its spread and potency. The results of these investigations will be published in a Station bulletin in the near future. The two parasitic wasps of the genus Tiphia, which parasitize grubs, and the tachinid parasite, *Centeter cinerea*, which attacks adult beetles, are established in certain towns.

The adult Japanese beetle is a pest of many trees, shrubs, and herbaceous plants, among the latter, soybeans. Field experiments planned to develop a method of control on this crop by spraying with certain insecticides did not yield very conclusive results due to the light infestation in 1944 (page 405).

The eastern field wireworm, *Limonius agonus* Say, is a serious pest of potatoes, and its practical control offers many difficulties. The principal crop loss brought about by wireworm activity is the degrade due to feeding holes in the tubers. The biology of wireworms, feeding activities, and the possibilities of control by baiting and by use of insecticides are being investigated (page 344).

In addition to the studies of the use of DDT on orchard pests mentioned above, the efficiency of this insecticide in controlling pests of vegetable crops has received attention (page 348). The control of flea beetles on tomato and potato plants was satisfactory, although a transient injury to the foliage of tomatoes occurred. In the control of the European corn borer on potatoes and corn, the results with DDT compared favorably with those with rotenone in derris. The control of potato leafhoppers was excellent.

The practical control of the European corn borer involves not only a consideration of the toxicity of certain insecticides and their application but also the relations of the corn plant to the survival of borers and their injuriousness. The results of our investigations to date will be published in a forthcoming Station bulletin.

Dithane (disodium ethylene bis dithiocarbamate), originally developed as a fungicide, was found by the manufacturer to be toxic to insects feeding on the foliage of plants when applied in solution to the soil where it could be taken up by the roots. In our experiments with beans and potatoes, the use of this material reduced the population of insects feeding on the parts of the plants above ground (page 353).

The use of cryolite as an insecticide has increased markedly during the last few years. For the control of pests of vegetable crops, it is usually applied as a dust diluted with some sort of carrier. The nature of the carrier used affects the toxicity of the cryolite, for a cryolite-talc dust (pH 9.1) was found less toxic to certain insects than a cryolite-pyrophyllite dust (pH 7.0) (page 357). It has long been known that cryolite should not be mixed with hydrated lime (pH about 12.0). We have found cryolite dust to be more effective than cryolite spray in controlling the Mexican bean beetle.

The application of any insecticide or fungicide to the foliage of plants is probably injurious to some extent. Benefits from the use of such chemicals arise when the pests injure the plants more than do the insecticides and fungicides. Bordeaux mixture injures potato plants, and in the absence of pests causes a decrease in the yield of tubers. This problem of injury by Bordeaux has been studied in cooperation with the Department of Plant Pathology and Botany and discussed in a paper published elsewhere.

Defoliating insects frequently attack elms, sometimes with disastrous results. Our shade trees are sometimes completely defoliated by cankerworms or elm beetles, or both, two or three years in succession. Just how conducive this is to attack and injury by other deleterious agents is not always clear. The results of a two years study of the effect of defoliation are given on pages 358 to 373.

Borers affect ornamental trees and nursery stock as well as trees growing in the forest. The dogwood borer is commonly found in dogwoods in this State and is particularly injurious to ornamentals. The biology of this insect has been studied and a satisfactory control method developed (page 373).

Household pests frequently occur in such numbers as to be extremely annoying even when not injurious to health. Such an outbreak of the incinerator beetle occurred in an apartment house last winter and is discussed on page 411.

The corpora allata of insects are glands of internal secretion, producing one or more hormones of great physiological significance. The general structure of these organs in mosquitoes is discussed on page 396.

Control Operations

The inspection of nurseries (page 308) and apiaries (page 313), plant quarantine enforcement, and gypsy moth (page 319) and Dutch elm disease (page 322) control were carried out as usual. The Department cooperates with the United States Fish and Wildlife Service in rodent control, and a brief report of this work is found on page 329. 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 Deputy in charge of mosquito control is published here as a matter of convenience (page 323).

Prevalence of Insect Pests

Some of the insect pests of orchards were more abundant in 1944 and others were less so than in previous years. The Japanese beetle (*Popillia japonica* Newm.), which is injurious to many plants as well as orchard trees and grapevines, was less abundant over much of Connecticut than in the immediate past. This decline was particularly noticeable in the southwestern part of the State. In the Naugatuck Valley, the infestation was somewhat heavier than in 1943, and the same is true of the northeastern part of the State, although in this latter region the injury to plants was negligible. In southern Connecticut, the summer drought was severe, and this undoubtedly was in great part responsible for the marked decline in the abundance of grubs in the soil as compared to 1943.

The most interesting development in apple pests was the discovery that the European apple sawfly (*Hoplocampa testudinea* Klug) was present in many orchards along the shore. This insect is discussed later in this report. The San José scale (*Aspidiotus perniciosus* Comst.) increased in abundance in apple orchards in the central part of the State during the past year. Injury by the apple redbug (*Lygidea mendax* Reut.) appears to be increasing. Early in the season, the European red mite (*Paratetranychus pilosus* C. and F.) and the green apple aphid (*Aphis pomi* DeG.) were abundant in some orchards but failed to do much harm after July. Comstock's mealybug (*Pseudococcus comstocki* Kuw.) threatened to become injurious in several orchards but the development of an outbreak was apparently checked by parasites. A serious outbreak of the eye-spotted budmoth (*Spilonota ocellana* Schiff.) occurred in one orchard in Middlefield. The tentiform leaf miner (*Callisto geminatella* Pack.) appeared in several apple orchards during the summer. The plum curculio (*Conotrachelus nenuphar* Herbst) was less abundant in apples than in 1943 but seems to have concentrated on plums and peaches. The white apple leafhopper (*Typhlocyba pomaria* McAtee) was not very abundant. The codling moth (*Carpocapsa pomonella* L.) was no more abundant than in 1943 and the infestation declined in the orchard where it was most abundant that year.

The infestation of the oriental fruit moth (*Grapholitha molesta* Busck) on peaches was generally low throughout the State.

Injury in pear orchards by the pear psylla (*Psyllia pyricola* Foerster) was moderate to severe.

The strawberry weevil (*Anthonomus signatus* Say) cut about 50 per cent of the buds in a small patch of strawberries in Branford and about 10 per cent in a large field nearby.

According to a survey made by the federal Bureau of Entomology and Plant Quarantine under the direction of Vance, the European corn borer (*Pyrausta nubilalis* Hübn.) was less abundant in the fall of 1944 than in the corresponding period in 1943. The number of borers *per 100 plants* in the fields surveyed is given below. In the summer the infestation was somewhat lighter in 1944, 7.4 borers *per*

County	1943	1944
Fairfield	....	177.4
Hartford	970.8	357.8
Litchfield	....	99.8
Middlesex	484.4	110.2
New Haven	979.2	68.0

plant, than in 1943, 9.5 borers *per plant*, in the fields sampled. The distribution of this pest was irregular. At Mount Carmel, the infestation on early sweet corn was the highest on record, about 3,000 larvae per 100 plants, including tillers. The second generation at the same locality was light, about 400 larvae per 100 plants. According to Clark of the federal Bureau of Entomology and Plant Quarantine, the parasitism of this insect by all exotic insect parasites in the Connecticut River Valley in Connecticut and Massachusetts was 11.6 per cent in the close of 1943.[1] The parasitism by *Lydella grisescens* was 1.2 per cent, by *Inareolata punctoria*, 6.8 per cent, and by *Macrocentrus gifuensis*, 3.6 per cent. *Macrocentrus gifuensis* is increasing in abundance in Connecticut and is now present from Long Island Sound to the center of the State, west to New Haven, and east to Willimantic and New London.

Vance estimates that the corn borer caused a loss of $32,805 to grain corn and $106,693 to sweet corn in Connecticut in 1944. This

[1] Clark (U.S.D.A., Agr. Res. Adm., Bur. Ent. and Pl. Quar., Insect Pest Survey Special Suppl., May 20, 1945) has reported the results of corn borer parasite collections in 1944. One hundred sixty-eight thousand corn borer larvae were collected in central Connecticut that year and 13,908 introduced parasites were reared from them as follows: *Inareolata punctoria* Roman 12,062 (7.2 per cent); *Lydella grisescens* R. D. 1,441 (0.2 per cent); *Macrocentrus gifuensis* Ashm. 400 (0.2 per cent); *Chelonus annulipes* Wesmael 5. These were distributed in borer-infested areas from North Carolina north and west to Wisconsin and Iowa. Four specimens of a native parasite, *Bassus agilis* Cresson, and one specimen of *Meteorus* sp. were also reared.

represents about 7 per cent of his estimate of the value of the grain corn crop and about 14 per cent of the value of the sweet corn crop.

The flea beetle (*Epitrix cucumeris* Harris) was abundant and injurious to potatoes and tomato plants early in the season. The potato leafhopper (*Empoasca fabae* Harris) was moderately abundant. The wireworm (*Limonius agonus* Say) was more prevalent and injurious than during the previous year. The European corn borer infestation on early potatoes was moderate, much less severe than in 1943. The federal Bureau of Entomology and Plant Quarantine conducted two surveys, one for the golden nematode (*Heterodera rostochiensis*), which is a recently discovered pest of potato plants on Long Island, and one for the potato tuber worm (*Gnorimoschema operculella* Zeller), a serious pest of potatoes in certain southern and western states. Neither was found in Connecticut. Although the tuber worm was reported from one town, no infestation was discovered when the locality was examined later.

Many of our common vegetable crop pests were not unusually abundant. The spinach leaf miner (*Pegomyia hyoscyami* Panz.) was quite common on spinach and beets in late May and early June. The Mexican bean beetle (*Epilachna varivestris* Muls.) was only moderately abundant early in the season, and the second generation caused very little damage. The striped cucumber beetle (*Diabrotica vittata* Fabr.) was relatively scarce and caused little damage. Cabbage caterpillars were troublesome early and late in the season, but were of little consequence in midsummer. The imported cabbage worm (*Pontia rapae* L.) was the principal species early and the looper (*Autographa brassicae* Riley) late. Aphids were troublesome at times on potatoes, tomatoes, peppers and cucurbits, but no severe outbreaks on a large scale occurred.

Certain pests of shade and forest trees were quite abundant. The fall cankerworm (*Alsophila pometaria* Harris) was unusually abundant in southern Connecticut and many shade trees and unsprayed apple orchards were completely defoliated in May. A rather heavy flight of moths in the late fall of 1944 indicates an abundance of this pest in 1945, although not so great as during the past year. The elms suffered again a month later when the elm leaf beetle became abundant, particularly in New Haven County. During the middle of the summer, the elm lacebug (*Corythucha ulmi* O. and D.) caused an extensive bronzing of elm foliage in the vicinity of Cornwall and Southington. The eastern tent caterpillar was very abundant on wild cherry and apple trees in southwestern Connecticut. The oak twig pruner (*Hypermallus villosus* Fabr.) was very numerous and caused an unusual fall of twigs in July and August. The fall webworm was also very abundant in August, particularly in the eastern part of the State. Defoliation of oaks by the orange-striped oak worm (*Anisota senatoria* A. and S.) was conspicuous in late summer in eastern Connecticut. A leaf beetle (*Blepharida rhois* Foerster) defoliated several staghorn sumac bushes in North Branford.[1]

[1] Reported by J. V. Schaffner, Jr.

Several pests of coniferous trees were injurious in some localities. Red pine plantations in North Branford and Southington were attacked by the looper (*Lambdina athasaria pellucidaria* G. and R.) and the sawfly (*Diprion frutetorum* F.), and the latter also infested pine plantations in Litchfield County.[1] In Southington and North Branford, the stands have suffered during previous years, many trees are dead or dying, and bark and wood-boring beetles are attacking them. The looper infestation in North Branford is declining. A pine sawfly (*Acantholyda erythrocephala* L.) was quite abundant on white pine along the Merritt Parkway (see page 420).

In cooperation with the Division of Foreign Plant Quarantines of the federal Bureau of Entomology and Plant Quarantine, we examined the soil about the roots of woody plants in several nurseries during the spring. Specimens collected were determined as to species by the Division. Nothing unusually significant was discovered. Larvae of *Brachyrhinus ovatus* L., *B. sulcatus* F., *Autoserica castanea* Arrow, *Popillia japonica* Newm., and many species of *Phyllophaga* were found, as would be expected. These are all known pests of nursery stock. Several other species of no economic significance were also found, although in small numbers.

During the year November 1, 1943, to October 31, 1944, 434 samples of insects were received at the office with requests for information about their injuriousness and control. They are grouped in economic categories in the following table.

TABLE 1. SUMMARY OF SPECIMENS RECEIVED, 1944

	Number of samples received
Fruit pests	40
Field and vegetable crop pests	26
Forest and shade tree pests	92
Timber and wood products pests	39
Pests of shrubs and vines	27
Flower garden and greenhouse pests	17
Pests of the household and stored grain	94
Soil and grassland inhabiting pests	26
Insects annoying to man and domestic animals	17
Parasitic and predaceous insects	19
Miscellaneous	37
	434

[1] Reported by J. V. Schaffner, Jr.

The following species were received five or more times.

TABLE 2. INSECTS RECEIVED FIVE OR MORE TIMES, 1944

	Times received
Elm leaf beetle, *Galerucella luteola* Mull.	29
Black carpet beetle, *Attagenus piceus* Oliv.	13
Termite, *Reticulitermes flavipes* Koll.	12
Carpenter ant, *Camponotus herculeanus pennsylvanicus* DeG.	10
Twig pruner, *Hypermallus villosus* Fabr.	9
Saw-toothed grain beetle, *Oryzaephilus surinamensis* Linn.	8
German cockroach, *Blattella germanica* Linn.	7
Japanese beetle, *Popillia japonica* Newm.	7
Euonymus scale, *Chionaspis euonymi* Comst.	6
Dermestid beetle, *Dermestes cadaverinus* Fabr.	6
Spinach leaf miner, *Pegomyia hyoscyami* Panz.	6
Pavement ant, *Tetramorium caespitum* Linn.	6
Eastern spruce gall aphid, *Adelges abietis* Linn.	5
Brown dog tick, *Rhipicephalus sanguineus* Latr.	5

About 60 species were determined for amateur entomologists.

INSPECTION OF NURSERIES, 1944

M. P. ZAPPE

The annual inspection of nurseries, as required by Section 2136 of the General Statutes, began on July 6, 1944. Two temporary nursery inspectors were employed during July and August. They were Messrs. F. A. Luddington and F. M. Richards, both teachers in the Hamden High School. Mr. L. A. DeVaux and the writer worked with the other men during July and August. On September 22, all inspections were completed. Occasional inspections were made after this date to see that nurserymen had made a proper cleanup of their nursery pests. A few strawberry growers sell strawberry plants and their fields were inspected during the latter part of June.

The nursery business was very good in 1944. Nurserymen had more sales than they could take care of, owing to shortage of help. As a result, many spring orders were left unfilled until the fall shipping season. The larger nurseries were in good condition but, in some of the smaller ones, the weeds were allowed to grow and by the end of the summer they were in poor condition.

Nursery pests occurred in about the usual numbers and no great amount of serious species was found. Out of a total of 297 nurseries, 123 were free from pests that required control measures. Forty-three different insect pests and eight plant diseases were found during the inspection period. Most of these were of a minor nature and were not considered serious.

There seems to have been an increase in wood borers during the last two years. Borers in linden, mountain ash, hawthorn and dogwood appear to be more abundant than formerly. The oak twig pruner, *Hypermallus villosus* Fabr., was quite abundant in one nursery. Usually, this pest only cuts small twigs from oak trees and is not considered of much importance. In one nursery, it was attacking purple beeches and was cutting off branches an inch in diameter. In several cases, it cut off the leader, thus spoiling the shape of the tree. The linden borer, *Saperda vestita* Say, was found to be causing serious damage to lindens in several nurseries and many trees had to be removed and burned.

Of the scale insects, oystershell scale was the most abundant and was present in 65 nurseries. Pine leaf scale was second with 53 nurseries found infested while in 1943 only 10 nurseries were infested with this scale insect. Spruce gall aphids reached a new low in 1944 with only 83 nurseries infested with both species. European pine shoot moth increased this year over the low of 1943, which was probably due to severe winter temperatures of the winter of 1942-43. Maples in 23 nurseries showed evidence of nectria cankers. Peach "X" disease was found in one nursery among some old trees that had been kept heeled in for several years. No "X" was found in any nursery that actually grows peach stock. The regulations under which peach stock may be grown are such that for several years no "X" disease has been found in the nurseries that grow peach trees, budded on seedlings. Leaf-feeding insects were rather scarce except that cankerworms did some feeding early in the season. At nursery inspection time, most of the trees had produced a new set of leaves and the injury was not conspicuous.

Only one nurseryman grew peach trees in 1944. These were grown under special conditions so that the stock would be free from "X" disease. These regulations require that all chokecherries be removed within a 500 foot zone around the peach blocks. This must be done before the seedlings are above ground and chokecherries must be kept out of this area until the trees are finally harvested.

TABLE 3. TEN-YEAR RECORD OF CERTAIN NURSERY PESTS

Pest	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944
Oystershell scale	93	87	84	53	49	57	77	68	78	65
San José scale	17	11	8	2	1	2	7	4	10	15
Spruce gall aphids[1]	285	337	306	312	216	231	227	210	140	83
White pine weevil	98	82	101	97	93	70	61	27	28	31
Pine leaf scale	42	72	60	25	50	48	46	23	10	53
European pine shoot moth	121	108	128	130	110	108	106	54	6	39
Poplar canker	28	28	26	20	14	15	15	11	28	12
Pine blister rust	2	0	4	5	3	3	4	0	2	1
Nurseries uninfested	16	26	25	32	19	33	32	126	148	123
Number of nurseries registered	372	380	377	402	399	376	356	331	318	297

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

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

A total of 297 nurseries were registered and inspected, but all have not been granted certificates as they have not completed the required cleanup of their pests. These nurseries have a total of 4,356 acres devoted to the growing of nursery stock. A classification of nurseries by size is given in Table 4.

TABLE 4. CLASSIFICATION OF NURSERIES BY AREA

Area	Number	Percentage
50 acres or more	16	5
10 to 49 acres	41	14
5 to 9 acres	29	10
2 to 4 acres	73	25
1 acre or less	138	46
	297	100

The list of nurserymen and number of acres varies from year to year. In 1944 the number of nurseries was less than in 1943. Some of the smaller nurseries are temporarily out of business, some that were carried as a side line have discontinued, and owners of others are in the armed forces.

Some of the nurserymen failed to register before July 1, 1944, and, as required by Section 2137 of the General Statutes, were charged for the cost of inspection. Eleven nurserymen paid the cost of inspection and $55.00 has been turned over to the treasurer of the Station to be sent to the State Treasury. Nurserymen who failed to pay cost of inspection and those who neglected to clean up their pests were not issued a certificate and therefore cannot legally sell their stock. The cost of inspecting the nurseries, including a few additional visits to see that the pests were properly eradicated, was $2,386.40, exclusive of traveling expenses.

Other Kinds of Certificates Issued

During the year, 121 duplicate certificates were issued to Connecticut nurseries to be filed in other states. Sixty-seven dealers' certificates were issued to stores and individuals who do not grow their own stock. No inspection is required before issuing these certificates as all dealers are obliged to buy their plants from certified nurseries.

Approximately 333 lots of nursery stock and other plant material were inspected and certified for private individuals. Four hundred and ninety-four blister rust control area permits were issued. These permit planting of currants and gooseberries in areas where there are no timber stands of white pine.

Inspection of Imported Nursery Stock

Certain kinds of foreign nursery stock are allowed to enter the United States at designated ports of entry under permits issued by the federal Bureau of Entomology and Plant Quarantine. These are released for transit to destination points where they are examined by state inspectors. Most of the nursery stock entering Connecticut consists of rose stocks which are grafted by florists and are grown for cut flowers in greenhouses. Since the beginning of the war, importation of rose stocks has practically stopped and florists purchase these stocks from the western states. During the past year, only one shipment of foreign rose stocks was received from England. This consisted of four cases containing 24,000 plants.

Miscellaneous plant material and seeds are also allowed entry into the United States under special permits issued by the Bureau of Entomology and Plant Quarantine. All of this material is sent to Washington, D. C., where it is examined by federal inspectors and, if free from injurious insects and plant diseases, it is reshipped to its final destination. No inspection is made by state men.

Miscellaneous material examined by federal inspectors in 1944 included:

100	raspberry plants
12	currant bushes
4	gooseberry bushes
2,800	orchids
7	house plants
1	peach tree
1	apple tree
1	grapevine
9	seakale roots
31	gladiolus corms
2	fritillaria bulbs
1	cyclamen
7¼	pounds onions
12¼	pounds seed
16	packets of seed

QUARANTINE ENFORCEMENT AND MISCELLANEOUS INSPECTIONS, 1944

M. P. Zappe and L. A. DeVaux

There are many state and federal quarantines that hinder the free movement of plants and plant material. These quarantines are designed to protect certain states and entire sections of the United States from serious insect pests that occur in some states. Naturally, this leads to considerable confusion when people try to ship plants or plant products from one state to another or to foreign countries. Nurserymen and others who ship plants are more or less familiar with these conditions but the average person knows little about such matters. The postal department and transportation companies know that it is illegal to accept plants and plant materials for shipment unless accompanied by a valid certificate of inspection. We are often called upon to inspect and certify such shipments and occasionally it is necessary to refuse certification on account of quarantines or state regulations. Fortunately, most of the requirements of nearby states are such that we can certify the materials. Most of the difficulty encountered is on long distance shipments, particularly into southern and western states.

The federal quarantine on the European corn borer was revoked several years ago, but many states have their own quarantines to prevent shipment of this insect within their boundaries. These quarantines allow the movement of host plants of the European corn borer into their states, provided the shipment is accompanied by a statement showing freedom from this pest. The only commodity that is affected to any great extent is corn. This is allowed entry into all states and Canada, provided that it is shelled and is certified to be free from European corn borer. During 1944, we were called upon to inspect and certify 309 lots of seed corn on account of these quarantines.

The oriental fruit moth has spread over a considerable portion of the United States and some of the states have lifted their quarantines on account of this insect. The quarantines prevent free movement of fruit, fruit containers and fruit trees, and the regulations are such that few nurserymen or others will go to the trouble and expense to ship into the states having such quarantines.

Since the Bureau of Entomology and Plant Quarantine established quarantines on account of the Japanese beetle and gypsy moth, the Experiment Station has worked cooperatively with the federal agency in their administration. At the present time there are four federal full time inspectors in Connecticut and two state men, authorized to issue federal certificates, making inspections and certifying materials on account of these two quarantines.

Mr. H. N. Bartley, in charge of quarantine enforcement, has supervision over Hartford, Tolland, Windham, Fairfield, Middlesex and New London counties and a few towns in eastern Litchfield and New Haven counties. The rest of the State is under the supervision of M. P. Zappe at the Agricultural Experiment Station in New Haven.

Japanese Beetle

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

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 district supervisors are now able to do the necessary scouting instead of the usual crews who carried on these scouting operations.

Inspection and Certification

The total number of plants certified for shipment on account of the Japanese beetle in 1944 was 1,582,920. These plants were contained in 1,331 shipments. Of these, 611 shipments were under an "A" certificate, used in shipments from nurserymen to customers, and 720 "B" certificates were used between classified nurserymen and carload shipments. Four shipments of sand were also certified. No inspections of farm products or cut flowers were made because no towns in Connecticut were within the areas that required such inspection and certification. During the year, two nurseries in the State treated nursery stock to be shipped out of the Japanese beetle quarantined area with the new approved ethylene dichloride dip under the inspectors' supervision. This method is becoming more popular with the nurserymen and may eventually replace soil treatments with arsenate of lead.

Gypsy Moth

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

Inspection and Certification

The total number of plants inspected and certified for shipment to points outside of the quarantined area was 1,794,823. There were 787,279 lots of forest products. Two hundred and sixty-five tons of quarry products, and 3,860 bales of evergreen products were also inspected and certified. A total of 4,286 certificates was used for this purpose.

Seed Inspection for Export

A large amount of seed is exported by Connecticut seedsmen to foreign countries, mostly to Central and South America. This required the use of 528 special certificates, covering 261 shipments of assorted vegetable seed. Frequently, the foreign regulations call for treatments of certain seeds to minimize the risk of carrying seed-borne fungous diseases and these are made under the supervision of an inspector.

INSPECTION OF APIARIES

M. P. Zappe

There has been no change in the personnel of the bee inspection service for several years. 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.

The winter mortality of bees this year was very much less than last year when nearly one third of the bees died during the winter months. This year the beekeepers lost only 5.44 per cent of their colonies. The winter was not as severe as the preceding one and quality of winter stores was better. Possibly the beekeepers gave their bees more protection and more food after the heavy losses of the winter of 1942-1943. The greatest losses this year occurred in Litchfield, Middlesex and Hartford counties and the smallest in New London County.

This season there were 2,451 apiaries inspected in the State, 184 less than last year, with a total of 12,360 colonies, a decrease of 2,543

TABLE 5. THIRTY-FIVE YEAR RECORD OF APIARY INSPECTION

Year	Number apiaries	Number colonies	Average number 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	2.57	.41
1921	751	6,972	9.2	2.64	.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	1.56	.234
1936	1,438	9,278	6.45	1.43	.221
1937	1,437	10,253	7.1	1.28	.18
1938	1,609	10,705	6.7	1.18	.177
1939	1,627	8,936	5.5	1.12	.204
1940	1,719	8,552	5.0	1.33	.268
1941	2,222	10,720	4.8	1.16	.239
1942	2,354	13,777	5.85	1.18	.201
1943	2,635	14,903	5.65	1.05	.186
1944	2,451	12,360	5.04	1.29	.256

from last year. This may be due to the large losses of bees during the winter of 1942-1943 which have not been made up by normal increases. The average number of colonies per apiary in 1944 was 5.04 as against 5.65 in 1943.

There was a slight increase in the amount of American foul brood this year. For the entire State, 3 per cent of the colonies were diseased against 2.5 per cent in 1943. There was a slight increase in nearly every county except Hartford which showed an increase of nearly 2 per cent. Fairfield and New Haven counties still have the highest per cent of foul brood and Tolland and Windham the lowest. All diseased colonies were burned, either by the inspectors or the owners. One colony of European foul brood was found in Fairfield County and one colony infected with sacbrood in Hartford and another in Middlesex County.

The cost of inspection was a little higher than it was in 1943. This was due to an increase in salaries to bee inspectors to offset the general increase in the cost of living.

TABLE 6. INSPECTION OF APIARIES, 1944

County	Apiaries: Inspected	Apiaries: Diseased (Am. foul brood)	Colonies: Inspected	Colonies: Diseased (Am. foul brood)	Per cent diseased	Per cent winter-killed
Fairfield	453	70[1]	2,264	135	5.96	4.46
New Haven	317	41	1,733	87	5.02	4.79
Middlesex	171	4[2]	961	10	1.04	8.43
New London	292	19	1,605	31	1.93	1.87
Litchfield	310	15	1,728	34	1.96	8.62
Hartford	522	24[2]	2,598	59	2.27	7.00
Tolland	188	6	677	6	.89	3.39
Windham	198	5	794	9	1.13	2.90
	2,451	184	12,360	371	3.0	5.43

[1] One apiary had one colony infected with European foul brood.
[2] One apiary had one case of sacbrood.

TABLE 7. SUMMARY OF INSPECTION

	Apiaries	Colonies
Inspected, 1944	2,451	12,360
Infected with American foul brood..........	184	371
Percentage infected	7.5	3.
Average number of colonies per apiary......		5.04
Average cost of inspection	$1.29	$ .256
Total cost of inspection, 1944....	$3,168.95	

Financial Statement

January 1, 1944—December 31, 1944

Disbursements

January 1 to June 30, 1944:		
Salaries	$ 911.25	
Travel	412.30	
Miscellaneous	11.30	
		$1,334.85
July 1 to December 31, 1944:		
Salaries	$1,185.00	
Travel	648.90	
Miscellaneous	.20	
		1,834.10
Total disbursements for 1944		$3,168.95

Registration of Bees

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

In 1944, 2,451 apiaries containing 12,360 colonies were inspected. However, only 1,609 apiaries consisting of 8,710 colonies were registered. This shows that 842 apiaries and 3,650 more colonies were inspected than were registered by the town clerks. No doubt some unregistered apiaries were not inspected by the apiary inspectors who did not know of their existence. Uninspected bees may be a source of foul brood infection for other bees in the community. Every effort is being made to have all beekeepers register their bees so that they may be inspected and treated if found diseased.

Honey Production

The year 1944 was not favorable to the production of honey in Connecticut, nor in New England as a whole. This was due to unfavorable weather conditions. There was a bad freeze in mid-May in many sections and the unusually dry season was damaging to nectar producing plants. The figures in the following table, taken from a report by the New England Crop Reporting Service of the United States Department of Agriculture, give the production of honey and beeswax for the year. Connecticut is by far the most important state in New England as far as beekeeping is concerned. There is a considerable discrepancy between the number of colonies of bees given here and the number inspected by our staff, as shown in the previous pages, but such a discrepancy presumably holds for the other states as well.

TABLE 8. HONEY PRODUCTION

State and Division	Colonies of bees 1943	1944	Production per colony 1943	1944	Honey production 1943	1944	Beeswax production 1943	1944
	Thousands		Pounds		Thousand pounds		Thousand pounds	
Maine	6	7	20	17	120	119	3	3
New Hampshire	3	3	35	16	105	48	2	1
Vermont	8	8	43	44	344	352	7	5
Massachusetts	17	18	26	15	442	270	13	8
Rhode Island	1	1	30	27	30	27	1	1
Connecticut	18	20	30	26	540	520	12	13
New England	53	57	29.8	23.4	1,581	1,336	38	31
United States	4,887	5,219	38.9	36.2	189,867	188,969	3,743	3,921

John T. Ashworth, Deputy in charge of gypsy moth control work for the past 24 years, retired from active service July 1, 1944. Mr. Ashworth, after several years' experience in gypsy moth control with the Bureau of Entomology of the United States Department of Agriculture, came to the Experiment Station June 1, 1917, as assistant to Mr. I. W. Davis, then Deputy. He succeeded Mr. Davis when the latter resigned, June 10, 1920.

During his entire career in the service of the State, Mr. Ashworth has exhibited those admirable personal and professional attributes which have aroused great respect for and the utmost confidence in his ability to do the job well. The efficient conduct of gypsy moth control work has reflected his capable administration. We wish him what he has well earned, many happy years.

Mr. Dolor LaBelle has been appointed Acting Deputy in charge of gypsy moth control.

GYPSY MOTH CONTROL

Dolor LaBelle and Roger B. Friend

Gypsy moth control work was carried on with a much reduced force again this year, as some of the men have been inducted into the armed forces and suitable replacements are not available. It has not been possible, therefore, to do as much scouting and mapping as in former years. Fortunately, little spraying was necessary, and we were able to accomplish this. Some scouting was carried on during the winter in Somers, Manchester, Glastonbury, Torrington, Simsbury, Granby and Stonington. All egg masses found were destroyed by creosoting. The most serious infestation was in the southern half of the city of Torrington. This was sprayed with lead arsenate in June. Type mapping, a description of which is given in the Report for 1940, was continued and the towns of Colebrook, Ellington, Hartland, Tolland, Union and Willington were completed.

A survey of defoliation caused by the gypsy moth was made during July in Litchfield, Hartford, Middlesex, Windham, Tolland and New London counties. Defoliation was confined to individual trees, most of them in Hartford and Tolland counties, a few in Litchfield, Middlesex, and New London counties. In no town was over one-half an acre involved. A total of four acres were 25 per cent defoliated; two acres, 50 per cent; three acres, 75 per cent, and five acres, 100 per cent. Although this is not at all serious, it is an increase over that of last year.

During July and August, a total of 655 traps for male moths were set out in the southern part of the Barrier Zone to determine whether or not the gypsy moth was present in the area. This work was carried out in cooperation with the federal Bureau of Entomology and Plant Quarantine which furnished the attractant. The area included the entire towns of Greenwich, Bridgeport, Easton, Fairfield, Monroe, Newtown, Redding, Southbury and Trumbull, and parts of Middlebury, Oxford and Woodbury. No male moths were captured. The federal Bureau of Entomology and Plant Quarantine set out 140 traps in Sharon and caught 60 male moths in 21 of them. During the years 1943 and 1944, traps have been set out in all of the southwestern corner of the State.

As in former years, we are indebted to the federal Bureau of Entomology and Plant Quarantine for work done in the western part of the State (in the Barrier Zone), and we hereby express our appreciation to Mr. R. A. Sheals, Chief of the Division of Gypsy and Browntail Moths Control, and Messrs. S. S. Crossman and H. L. Blaisdell, Assistant Chiefs of the Division. The federal crews carried on control operations in 21 towns in Litchfield and New Haven counties. They scouted 214,377 acres of open and woodland areas, destroyed 1,190 egg masses, sprayed 10 infested areas with 3,719 pounds of cryolite, applied 1,944 bands, and crushed 389 larvae.

Cryolite is an effective insecticide and is not injurious to cattle at the concentrations used, that is, about nine pounds to 100 gallons, with suitable adhesives and wetting agents. Scouting was carried out in those parts of the Zone not examined in recent years. One infestation was found in Southbury and another in Wallingford. In many places in the Barrier Zone in Litchfield County, an increase in infestation was noted.

The condition of the egg masses in the spring, that is, the number of eggs per mass and the percentage of hatch, often gives an indication of the trend of the gypsy moth population. During April, 1944, egg masses were collected in Litchfield, Hartford, Windham and New London counties. These were held outdoors until the eggs hatched. The results show a large number of eggs per mass and a high survival. This may be compared with the figures for the

Number of egg masses collected	147
Number of eggs per mass	687
Number of eggs hatched per mass	596
Per cent hatched	86.7

spring of 1940 and of 1943 as given in the Report for 1943 (pages 255-256). Temperatures during the winter of 1943-44 were not low enough to affect seriously the viability of the eggs, as indicated by the table below which gives the sub-zero records at four stations.

TABLE 9. MINIMUM TEMPERATURES IN NORTHERN CONNECTICUT (Fahrenheit)

Date	Cornwall (Cream Hill)	Falls Village	Hartford	Putnam
Dec. 16, 1943		−7°		
Dec. 23, 1943				−1°
Dec. 24, 1943	−4°			−7°
Jan. 17, 1944		−9°		−1°
Feb. 13, 1944			−1°	
Feb. 14, 1944	−10°	−15°	−2°	−1°

On June 22 and 23, the gypsy moth control crew sprayed about six acres of a stand of hemlocks at Sandy Hook at the request of the State Park and Forest Commission. In past years, the trees, many of them 90 to 100 feet high, had been injured by the looper *Lambdina athasaria pellucidaria* G. and R. A flight of moths was noted the last of May and the first of June, and further defoliation was anticipated unless the trees were protected. The treatment required 279 pounds of lead arsenate and 62 quarts of fish oil. An inspection of the stand later in the year revealed that no defoliation occurred.

TABLE 10. SUMMARY OF CONTROL OPERATIONS, 1943-1944

County	Number of towns worked	Infestations found	Egg masses creosoted	Number colonies sprayed	Pounds insecticide used	Larvae, pupae crushed	Bands applied	Miles scouted	Acres scouted
Fairfield	0	0	0	0	0	0	0	0	0
Hartford	2	4	3,302	0	0	0	0	0	0
Litchfield[1]	15	54	1,121	9	3,220[2]	389	1,679	0	152,505
	1	1		1	1,936[3]				
Middlesex	3	1	9	0	0	0	0	1	0
New Haven[1]	6	2	69	1	499[2]	0	265	0	61,872
New London	1	1	2,780	0	0	0	0	0	0
Tolland	1	2	5,290	0	0	0	0	0	0
Windham	0	0	0	0	0	0	0	0	0
Totals	29	65	12,571	11	5,655	389	1,944	1	214,377

[1] All federal Bureau of Entomology and Plant Quarantine, except the one infestation sprayed with lead arsenate.
[2] Cryolite.
[3] Lead arsenate.

DUTCH ELM DISEASE

M. P. Zappe

During the year 1944, the U. S. Department of Agriculture has been obliged to stop removing diseased trees found by their inspectors. Their scouting operations have been largely confined to the area just north and east of the territory under quarantine. Under the new plan, the U. S. Department of Agriculture scouts worked mostly in Litchfield and Hartford counties and the eastern towns in Middlesex County. The results of their scouting show an eastward spread of the disease. This is particularly true in the northern part of the State, so that at present the disease has been found in practically all towns in Hartford County.

The same is true of Middlesex County, but in this county only two new infected towns were found this summer. In New London County the towns of Lyme and Bozrah were added to the list of infected towns, although diseased trees had been found in Old Lyme at intervals since 1934. The town of Vernon is the first town infected in Tolland County.

In the following 18 towns Dutch elm disease was found for the first time in 1944: Avon, Bozrah, Chester, East Granby, East Hartford, East Windsor, Enfield, Glastonbury, Killingworth, Lyme, Manchester, Rocky Hill, Simsbury, South Windsor, Suffield, Vernon, Wethersfield and Windsor. In these towns, the tree wardens and selectmen were notified of the conditions existing, given the location of the trees and urged to see that all diseased trees were removed and proper precautions taken to reduce chances of rapid spread of the disease from these centers.

In the towns where the disease has been present for several years, the number of diseased trees has increased rapidly. This is quite serious in some of the cities in Fairfield and New Haven counties. Under the present conditions, the cities are unable to obtain sufficient help to eliminate immediately the trees when they are found. When diseased trees are left until bark beetles emerge, there is great danger of nearby elms becoming infected with the disease.

The federal scouts looking for diseased trees in towns not known to have the Dutch elm disease are now using methods of detecting the disease before leaf and bark symptoms are present. Formerly they depended upon these symptoms but now they take samples of bark beetles, their galleries and bark from dead and dying trees and also from large broken branches. By this method they often find the disease present in a town where the elm trees did not show any visible leaf or twig symptoms. Where clean-up operations are carried on by the town authorities, it is an advantage to be able to eliminate this material before any valuable elms are lost.

For two years, we have been placing elm trap logs in the eastern part of the State in order to determine the areas infested with *Scolytus* *multistriatus* Marsh. Both years we were unsuccessful in obtaining evidence of this bark beetle's work in the trap logs, but did obtain plenty of larvae of *Saperda tridentata* and *Magdalis* sp. In a few cases, we saw work of *Hylurgopinus rufipes*, but very little of that. We suspect that something was wrong with the methods used because in one case at the site of a set of trap logs a small elm was cut and left leaning into other trees. This cut elm produced evidence of *Scolytus* work but cut logs only two feet away were free from any sign of the beetle.

The men employed by the Bureau of Entomology and Plant Quarantine who are scouting for Dutch elm disease in eastern Connecticut have furnished us with records of towns known to be infested with *Scolytus multistriatus*. This insect is now known to be established in 25 towns east of the Connecticut River. It is possible that the rest of the towns in Connecticut are also infested but as yet we have no definite records to confirm this. The following towns and all those lying west of them are known to be infested: Somers, Ashford, Mansfield, Windham, Franklin, Salem and East Lyme. In addition to these towns, this insect has been found in the town of Preston.

MOSQUITO CONTROL IN 1944[1]

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

The primary duty of the Board at present is the maintenance of 11,000 acres of salt marshes ditched for mosquito control. This work includes clearing of ditches and repair of tide gates, dikes, beach culverts and other structures which comprise the complete system necessary to prevent mosquito breeding on certain "accepted" salt marsh areas. About 7,000 acres remain to be accepted for state maintenance when sufficient funds and labor become available.

The Board also has authority to make surveys and inspections of mosquito breeding areas on request, and supply technical advice where control work is contemplated.

Mr. Noyes P. Farnell, formerly employed for maintenance work in Stonington and Groton, returned on October 9, 1944, and was assigned as foreman of the New London District. The maintenance work of this season was much limited, due to shortage of labor, and very little routine work of reconditioning ditches or repairing dikes and tide gates could be undertaken. Work was necessarily confined to small areas where mosquito breeding was discovered or threatened to develop. Large areas in poor condition cannot be improved until

[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.

major construction affecting these areas is completed. These conditions were brought about by storm damage, natural depreciation, or the need for improved drainage outlets. The repairs and corrections require considerable study and the expenditure of fairly large sums of money.

The status of these major repairs is reviewed below.

Work on the Sybil Creek, Branford, tide gate was started this fall; the engineering, letting of the contract, and inspection were supervised from the State Comptroller's office. The contract was awarded and construction started about November 20, 1944.

On December 7, 1944, tentative arrangements were made with the State Highway Department to construct new tide gates on a proposed new bridge on Hammock River, Clinton, at Beach Park Road. The Rushy Meadow outlet in Westbrook will be rebuilt by a contractor.

A request for funds has been prepared for presentation to the Legislature to cover the cost of the following work:

Great Harbor Dike, Guilford:

1,500 feet of stone riprap with earth core.
200 feet of timber jetty for sluice.
Install slots for flood boards (request of wild life interests).
Repair gates and bulkhead.
Recondition ditches.

Stony Creek Dike, Branford:

Rebuild 100 feet of dike damaged by hurricane of 1944. Earth core with stone riprap protection on both sides. Sheet piling may be necessary.
Clear debris of old dike off meadows.
Retop with gravel remaining dike and add riprap protection.

Indian River Tide Gate, Clinton:

Install tide gate north of Post Road near site of old tide gate.
Reditch salt marsh.

Hammock River Marsh, North of Post Road Route #1, Clinton:

Dredge creek and reditch marsh.

Farm River (East Haven River) Tide Gate, East Haven:

Repair dike damaged by hurricane of 1944.
General repairs to tide gates and structure.
(This is property of the Town of East Haven.)

West Silver Sands Meadow, East Haven:

Dredge main ditch, correct culverts and recondition ditches.

There has been an increase in interest in the control of fresh water species in recent years and, more especially, since military personnel are returning to this country from highly malarial parts of the world. There is some danger that the incidence of malaria may increase in this State in the near future, and it is necessary to form some conception of the extent of Anopheles breeding. This Board, therefore, made a survey this season in order to locate the sources of the malarial mosquitoes and their abundance, and at the same time determine the breeding places of common pest mosquitoes. The field work was done by biology teachers and others in areas within reasonable travel distance from their homes. Twenty-seven towns were covered in the period through July, August, and the first half of September. This information will be placed in the hands of the respective town officials upon request.

This mosquito survey was preliminary and could not indicate a complete census of the mosquito population in any locality, because nearly all areas were visited but once. Hand collections of adult mosquitoes were made only where these were found to be very abundant in the course of the scouting. The work was confined to examining suspected breeding places, such as swamps, streams, woodland pools, ponds, ditches, culverts and every structure or receptacle which a reasonable search would reveal. Mosquito larvae were collected by dipping up water containing larvae, and this was delivered to the State Experiment Station for identification of species. Numbers on the jars corresponded with numbers on a town map identifying the exact spot where collections were made. The larvae were examined and identified by Dr. Dietrich Bodenstein, and a systematic record made for each town surveyed. About 10,000 specimens were examined, consisting of 17 different species. Three of these species were collected in the adult stage only, two of them being early spring breeding species and one, a species the larva of which does not come to the surface.

Inasmuch as the survey did not begin until the last of June, species that breed early in the season could not be found in the larval stage. Moreover, the lack of rainfall during the late spring and summer prevented mosquito breeding which normally occurs in temporary pools. On the other hand, there may have been an unusual amount of breeding in streams, as the dry season increased the amount of quiet water in them. The results of the survey cannot, therefore, give reliable data on the normal relative abundance of the different species. It should be kept in mind that this survey was carried out during the Anopheles breeding season, so if these mosquitoes were present, they should have been found.

The following table gives the number of times the larvae of each species were found, each locality being sampled once except for some places in Danbury, Norwalk, Wethersfield, and Waterford which were sampled twice. Of the 1,225 samples taken, 214 contained larvae of *Anopheles quadrimaculatus*. This species was found in every town surveyed, as shown in Table 12. Although the method used in the survey does not enable us to estimate with certainty the relative abundance of adults of *A. quadrimaculatus* in the different areas, certainly this mosquito was found more frequently in the southwestern part of the State than elsewhere. It breeds particularly in clear,

TABLE 11. 1944 COLLECTIONS

Species	Times collected
Anopheles punctipennis	777
Culex apicalis	330
Anopheles quadrimaculatus	214
Culex pipiens	101
Uranotaenia sapphirina	47
Aedes vexans	27
Culex territans	20
Anopheles walkeri	11
Psorophora ciliata	4
Anopheles crucians	3
Culex salinarius	2
Aedes canadensis	2
Aedes sollicitans	1
Anopheles barberi	1
Mansonia perturbans	Adults only
Aedes intrudens	" "
Aedes cantator	" "

quiet water with some floating vegetation or debris. The larvae were found most frequently in late July, August and September.

Referring again to Table 11, *Anopheles punctipennis*, a poor carrier of malaria, was found more frequently than any other species. *A. walkeri* and *crucians*, likewise poor carriers of malaria, were found rarely. As a group, Anopheles was more commonly found than all other species combined. *Culex apicalis* breeds throughout the season but is said not to attack man. *Culex pipiens* is the common house mosquito and although not found as frequently as some others, may be more of a pest because of the nature of its breeding places. *Uranotaenia sapphirina* is presumably a rather rare mosquito, and its relative abundance is surprising. In normal years, *Aedes vexans* is undoubtedly our most common fresh water Aedes and it migrates considerable distances. There are probably two main broods, one in late spring and one in late summer, but this may be entirely a matter of the occurrence of rain-filled pools. Its relative scarcity in our samples is due to dry weather. *Culex territans* is closely related to the house mosquito, has similar habits, and looks the same. *Psorophora ciliata* is distinctly a flood-water mosquito, by far the largest species in the northeastern United States, and a vicious biter. It is not common. *Culex salinarius*, a relatively uncommon species, breeds in marshy areas and also in rain barrels. *Aedes canadensis* is one of our commonest woodland mosquitoes and one of our earliest spring species. The larvae occur in woodland pools in April and May. The adults do not migrate far. *Aedes sollicitans* is our common salt marsh mosquito. *Mansonia perturbans*, collected in the adult stage only, should be mentioned. The larvae of this species attach themselves to the roots and stems of plants below water and do not come to the surface. The adults bite viciously and migrate considerable distances. In Farmington, the adults were collected in some numbers and this

TABLE 12. AREA SURVEYED, 1944

Area	Date	Number of localities examined	Mosquitoes found in	*A. quadrimaculatus* found in
I. New Canaan	8/28-8/31	27	17	7
Darien	8/17-8/28	78	42	19
Norwalk	6/29-7/29	72	41	5
	8/1 -8/25	125	41	10
Westport	7/5 -7/31	138	80	13
II. Danbury	7/1 -7/19	103	58	6
	7/25-8/28 (repetition)	88	57	15
Ridgefield	8/17-8/26	53	45	28
Bethel	7/16-8/14	51	25	5
III. New Haven	8/10-8/21		17	6
Hamden	7/3 -8/9		35	2
IV. West Hartford	7/14-7/24	58	54	4
Farmington	7/24-8/7	82	27	6
Bristol	8/4 -8/11	74	60	8
Plainville	8/14-8/16	31	21	6
New Britain	7/31-8/3	33	26	1
Newington	7/10-7/14	43	39	3
Wethersfield	7/1 -7/7	44	33	0
	7/27-7/28 (repetition)	44	17	5
Rocky Hill	8/17-8/30	50	44	11
Berlin	8/24-9/2	86	68	14
V. Vernon	8/31-9/16	31	21	1
Windsor	8/23-8/30	70	33	4
Manchester	7/24-8/5	125	63	5
East Hartford	8/1 -8/15	68	40	2
Glastonbury	8/16-8/22	80	39	2
VI. Waterford	6/29-8/29		72	9
	7/27-8/29 (repetition)		35	4
New London	6/23-8/12		20	3
Groton	6/28-8/26		39	5
Stonington	8/21-8/24		16	5
			1,225	214

may be the principle species involved in the complaints of mosquito nuisance in part of that town.

As far as *Anopheles quadrimaculatus* is concerned, the survey indicates it occurs all over Connecticut, is more abundant in the southwestern part of the State, and breeds throughout the summer.

Requests for information on mosquito abatement are being received from inland areas in increasing numbers each year. We are unable to investigate all complaints from individuals, but give special attention to requests from health officers and other town officials or civic improvement associations. Upon investigating areas where complaints originate, we frequently find neither breeding places nor mosquitoes on the wing. The pools may have dried up, and the adults may have migrated into and out of the area. Early broods of adults, emerging in April and May, can infest an area for weeks after their breeding places have disappeared. If the mosquito nuisance in inland areas is to be really abated, each town should undertake control measures from April until October.

Officials of several towns and cities will probably initiate local mosquito control work in 1945, and the few suggestions which follow may be of assistance. Successful mosquito elimination work requires some study and preparation by a capable person, preferably on a full time basis. Maps should be prepared showing all water courses, ponds, springs, ditches, improperly graded roadside gutters, sink holes, swamps, dumps or any other natural or artificial means of containing water. This map, together with daily records of inspections, description and behavior of potential breeding places, treatment and costs, provides a necessary part of a continuing mosquito control program.

Unnecessary collections of water and unused articles which may hold water, no matter how small, should be disposed of as soon as feasible. Screen necessary water containers. Backyard inspections may be necessary. Regular inspection of every potential area is essential, as it requires only 10 to 14 days for a brood to develop.

Decide to treat breeding spots difficult to eliminate by selecting the most practical and effective method which will be most permanent for each particular case. The following order for considering choice of treatment is suggested: 1, fill; 2, drain; 3, correct grade (streams and ditches); 4, deepen margins, remove vegetation and stock with fish (ponds); 5, flush by changing water level every two weeks (ponds and reservoirs); 6, oil every two weeks or oftener as required and only when larvae are present. Number 2 fuel oil is recommended. Apply by spray or small solid stream at the rate of about two ounces for each 10 square feet of water surface.

Shallow woodland pools containing rotting leaves should receive attention very early in the season. Spray in February or March, before ice has entirely disappeared from the pools, to avoid fire hazard and to destroy the first, and probably the only, brood of mosquitoes from those spots for the season. Other potential breeding spots would be treated as best judgment decides.

One species of mosquito, *Mansonia perturbans*, a persistent nuisance, is sometimes found in great numbers and is difficult to eliminate. As mentioned before, the larvae and pupae remain submerged by attaching themselves to stems or roots of swamp vegetation, and are not taken in routine collecting. Oiling, therefore, is not effective and drainage is the only means of destroying this species.

Printed matter concerning malaria and the elimination of malaria carrying mosquitoes may be obtained from the State Department of Health, State Office Building, Hartford, Connecticut. The following publications are recommended for anyone wishing to make a thorough study of mosquitoes and mosquito control and may be obtained from the publishing company:

"Mosquito Control", by Herms and Gray, 1940. $3.50. Published by The Commonwealth Fund, 41 East 47th Street, New York, N. Y.

"Handbook of the Mosquitoes of North America", by Robert Matheson, Second Edition, 1944. $4.00. Published by Comstock Publishing Company, Inc., Ithaca, N. Y.

"The Mosquitoes of New Jersey and Their Control", by Thomas J. Headlee, 1945. $4.00. Published by Rutgers University Press, New Brunswick, N. J.

RODENT CONTROL

Francis B. Schuler[1]

Fish and Wildlife Service, Division of Predator and Rodent Control, U. S. Department of the Interior

During the past year, studies were continued on the population fluctuations of the meadow mouse (*Microtus pennsylvanicus*) and the testing of various rabbit repellent mixtures. This spring a preliminary study was initiated, in cooperation with Mr. F. W. Southwick, Department of Horticulture, Storrs Agricultural Experiment Station, on the effectiveness of methyl bromide as a fumigant for controlling rodents in cold storages.

From the control point of view, methyl bromide is an effective fumigant for the elimination of these pests. Further studies are necessary, however, to determine its effects on the flavoring and ripening of the fruit, particularly apples. Also, a practical method of application in the storage has yet to be worked out.

The October Microtus census indicates that the mouse population is definitely low this fall. This condition is probably related to the downward trend of the population, which was noticeable last fall, after the high year of 1942. Due to the drought of the past two growing seasons, the resultant lack of abundant food and cover undoubtedly was a further check on the population.

Fourteen repellent mixtures were tested on penned cottontail rabbits during the past winter. Due to the high mortality among the experimental animals, this work was curtailed.

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[1] Mr. Schuler is now in military service. The above brief summary of his work is essentially that printed in the 1944 Report of the Director of this Station.

REPORT ON PARASITES

Philip Garman

During 1944, the parasite laboratory at New Haven continued in operation and the staff produced a total of 103,177 Macrocentrus, of which 65,000 were liberated in Connecticut orchards. A total of 304 orders were filled, representing 123 individual orchards. The number of parasites released represents a considerably greater number than were distributed last year and we were able to all all of the orders received. The increase in production was largely due to a change from the usual method of breeding to the utilization of a new host, the potato tuber moth. This entailed construction of new cages and involved considerable experimentation with methods of handling. As a result of the experience gained this year, more parasites than ever should be produced next year. It is our hope that enough parasites may be bred in 1945 to supply not only the peach growers but also to meet our own demands for experiment.

Parasites for the mealybug continued to be received from the U. S. Department of Agriculture laboratory in Virginia and collections of bugs were made in 11 localities and seven different apple orchards. Parasites reared from these collections indicate that the species introduced has been doing good work and is actually cutting down the infestation in several places. We are still hopeful that stocks of the effective parasites may be bred at New Haven and some progress is being made. So far, however, the situation seems to be satisfactory in the orchards covered and shipments from Virginia have been ample to take care of it. Should the need arise, laboratory breeding will be started on a more extensive scale.

This year both breeding and distribution of fruit moth and mealybug parasites have been under the supervision of Mr. W. T. Brigham.

Parasites and diseases of the Japanese beetle have also been studied extensively in field and laboratory by members of the staff. It can now be said with certainty that the population of beetles is declining in southwestern Connecticut. On the other hand, increases have been noted east of Hartford, in the Naugatuck Valley and north of Danbury. Both disease and parasites appear to be on the increase and the dry summer has affected the beetle adversely.

STATUS OF THE NATURAL ENEMIES OF THE JAPANESE BEETLE IN CONNECTICUT

J. C. Schread

"Milky" disease experimental plots established from 1939 through 1941 are beginning to show good results. The oldest established experiments, those of 1939, had an average of 38.3 per cent diseased grubs during the month of June, 1944. Plots established the following year, 1940, revealed an average grub infection of 29.9 per cent. Those established during the season of 1941 showed a 25.8 per cent infection in 1944. It is readily seen that the length of time the experiments have been established seems to be of some importance in relation to degree of infection. Data accumulated as a result of the diggings made in 1943 and 1944 in the 1939-40-41 experimental plots show an average of 30.90 per cent diseased grubs occurred in all plots in 1944 in comparison with 24.08 per cent in 1943. The grub populations remained practically the same for both years, an average of 2.4 grubs per square foot in 1943 and 2.3 in 1944.

Check plots ranging in distance from 100 feet to one-half mile from respective experimental plots were examined. The average percentage of disease, 31.74 in the checks, was virtually the same as in the treated plots. Data in Tables 13 and 14 indicate the disease is spreading more in some areas than in others.

The towns of New Canaan and Bloomfield were set aside as check areas. No spore dust distribution was made in either of them. Samples of grubs were taken from eight localities in New Canaan and four in Bloomfield. The average of diseased grubs dug in New Canaan was 6.16 per cent, whereas in Bloomfield no diseased grubs were found. Of the eight localities from which grubs were taken in New Canaan, five, or 62.5 per cent, produced diseased Japanese beetle larvae, 5.2 per cent disease on the outskirts of the town and 18.5 per cent in the center of the town. Whether or not diseased grubs found in New Canaan were the result of the spread of the bacteria from surrounding towns that had received treatment several years earlier is not known. "Milky" disease is known to occur naturally in some localities.

The rapidity of natural spread of *Bacillus popilliae* from a single point of soil inoculation to adjacent areas was studied. During the two years the experiment was in progress, diseased grubs were found on only two occasions—once in 1943 and the second time in 1944, at distances ranging from 14 to 18 feet from the treated spot. The average grub population in 1943 was 9.7 grubs per square foot; in 1944, it was 5.0 grubs per square foot. The incidence of disease in both cases was extremely low. Hence, it seems that under some conditions some time is necessary before natural spread of the bacteria can be expected from a single point of inoculation, especially when the treated spot is protected, preventing tracking of the bacillus into untreated areas.

TABLE 13. RESULTS OF EXAMINATIONS OF "MILKY" DISEASE EXPERIMENTAL PLOTS—1944

Location of plot	Year plot was established	Date of digging	No. grubs dug	Av. grubs per sq. ft.	No. grubs examined	No. grubs diseased	Per cent diseased
Seaside Park, Bpt. Plot A	November, 1939	June 29	59	2.9	55	26	47.2
Seaside Park, Bpt. Plot B	Oct. 17, 1939	June 16	76	3.8	70	24	34.2
Seaside Park, Bpt. Plot C	Oct. 17, 1939	June 17	11	0.55	9	4	44.4
Stamford Hospital	May, 1941	June 19	105	5.2	89	22	24.7
Keney Park, Hartford	May 13, 1940	June 20	74	3.7	62	38	61.2
Cummings Park, Stamford	Oct. 29, 1940	June 23	111	5.5	99	47	47.4
East Rock Park, New Haven	Oct. 20, 1939	June 23	2	0.2	2	2	100.0
Brooklawn Country Club, Fairfield	Oct. 26, 1940	June 26	45	2.2	18	9	50.0
Tamarack Country Club, Greenwich	Nov. 7, 1940	June 27	100	5.0	19	3	15.7
East Hartford Country Club, East Hartford	May, 1941	June 28	22	1.1	16	10	62.5
Mountain Grove Cemetery, Bpt.	May, 1941	June 30	4	0.4	4	1	25.0
Mountain Grove Cemetery, Bpt.	Oct., 1941	June 30	3	0.15	2	1	50.0
Goodwin Park, Hartford	April 3, 1941	July 6	5	0.25	5	2	40.0
Colt Park, Hartford	May 22, 1940	July 6	14	2.33	12	6	50.0

TABLE 14. CHECK PLOTS IN "MILKY" DISEASE EXPERIMENTS—1944

Location of check	Year plot related to check was established	Date of digging	No. grubs dug	Av. grubs per sq. ft.	No. grubs examined	No. grubs diseased	Per cent diseased
Seaside Park, Bpt. Plot A	November, 1939; check 25 yds. from treated	June 29	28	2.8	28	19	67.8
Seaside Park, Bpt. Plot B	Oct. 17, 1939; check 50 yds. from treated	June 16	53	5.3	50	25	50.0
Seaside Park, Bpt. Plot C	Oct. 17, 1939; check 25 yds. from treated	June 17	77	7.7	72	5	6.9
Stamford Hospital	May, 1941; check 100 ft. from treated	June 19	21	4.2	23	14	60.8
Cummings Park, Stamford	Oct. 29, 1940; check 50 yds. from treated	June 23	16	2.6	18	9	50.0
East Rock Park, New Haven	Oct. 20, 1939; check ½ mile from treated	June 23	43	4.3	37	22	59.4
Brooklawn Country Club, Fairfield	Oct. 26, 1940; check 100 ft. from treated	June 26	32	4.0	30	15	50.0
Tamarack Country Club, Greenwich	Nov. 7, 1940; check 200 yds. from treated	June 27	163	20.3	82	25	30.4
East Hartford Country Club	May, 1941; check 150 yds. from treated	June 28	15	1.5	12	8	66.6
Mountain Grove Cemetery, Bpt.	May, 1941; check 50 yds. from treated	June 30	1	.12	1	1	
Colt Park, Hartford	May 22, 1940; check 100 yds. from treated	July 6	5	2.5	5	3	60.0
Seaside Park, Bridgeport	November, 1939; check 50 yds. from treated	July 7	63	1.7	63	19	30.1

TABLE 15. INCIDENCE OF DISEASE EXPRESSED IN PER CENT

Method of application	Spot dusting	Broadcast	Spot dusting	Broadcast	Spot dusting	Broadcast	Spot dusting	Broadcast	Spot dusting	Broadcast
Dosage in pounds	1/8		1/4		1/2		3/4		1	
Plots	1	2	3	4	5	6	7	8	9	10
May 29	0.0	0.0	0.0	0.0	7.6	4.5	5.2	0.0	0.0	0.0
June 6	0.0	13.6	12.5	0.0	11.1	27.2	14.2	8.3	9.0	27.2
June 14	0.0	8.3	20.0	40.0	12.5	41.6	0.0	0.0	0.0	0.0
June 20	0.0	0.0	0.0	0.0	100.0	0.0	16.2	16.6	0.0	33.3
June 28	0.0	16.6	0.0	66.6	33.3	25.0	40.0	80.0	66.6	0.0
July 6	50.0	100.0	100.0	100.0	33.3	100.0	100.0	50.0	100.0	33.3
July 11	0.0	0.0	0.0	0.0	100.0	0.0	100.0	100.0	100.0	100.0

Note: In check plots at a distance of 50 yards from the treated plots, 18.1 per cent diseased grubs were found. However, this was on only one occasion.

In a series of 10 experiments from which significant results were obtained in one year, the "milky" disease spore dust was used in amounts varying from one-eighth of a pound to one pound to each 1,000 square feet of lawn area. The materials were applied September 21, 1943.

From an application of one-half pound of spore dust to 1,000 square feet of turf in early fall, good results were obtained in the spring from late May on. Heavier dosages of three-quarters of a pound and one pound seemed to be no more effective.

Owing to the necessity of considering the economy of the control measure, it seems advisable to use from one-quarter to one-half pound of spore dust to every 1,000 square feet of grass area, rather than a lighter or heavier application, especially when it is desirable to obtain control of a serious grub infestation within a year. When the above recommendations are followed, it can be expected that the major part of a heavy Japanese beetle grub population will become diseased at the height of the feeding period in the following spring. Moreover, a minimum of turf injury results during the critical period of grub activity owing to reduced vitality of the individuals. By waiting several years, comparable results may be obtained when one-eighth of a pound or less of spore dust is used.

Although data accumulated during late June and early July, relating to three-quarters and one pound applications, favor these heavier dosages of spore dust, it is not at this time that the bacillus is most urgently needed, because the beetle has then passed the period in its life cycle vulnerable to the organism and no amount of spore dust will prevent emergence of adults. In the presence of any known concentration of *Bacillus popilliae*, especially a heavy one, high percentage of diseased grubs in early July can usually be ascribed to a much reduced grub population at that time of the year, explained by the transformation of healthy grubs to the pupal or adult stage during June.

As the investigation developed, it became clear that soil temperature is apparently a limiting factor in the effectiveness of the "milky" disease, irrespective of the amount of material used or the density of the grub population. Subsequent to May 4 to 6, the temperature was sufficiently high in the upper three inches of soil for *Bacillus popilliae* to develop in the bodies of Japanese beetle grubs. The progress of the disease, however, was slow at lower soil temperatures, and it was not until June and early July that any quantity of grub material taken from the experimental plots indicated the presence of the bacterium.

Grub density as well as the amount of spore dust used is fundamentally important in determining the rapidity of establishment and spread of the organism. Plots in which the highest grub populations occurred resulted ultimately in a more rapid and consistently higher percentage of disease. Whenever the grub population per square foot of turf is low, the use of spore dust equal in amount to that employed where the grub population is high will in all probability necessitate a longer time for the disease to become established and will perhaps be accompanied by a slower build-up in percentage of diseased grubs. The incidence of disease was more rapid in the plots in which the spots of "milky" disease were laid closest together.

It is somewhat difficult to evaluate the two methods employed in distributing the spore dust, whether to spot-dust it with a corn planter or to mix it thoroughly with sand, loam or fertilizer and broadcast by hand or apply with a lime spreader. Both the spot and broadcast

TABLE 16. RELATIVE ABUNDANCE OF INSTARS, 1944
Figures are number of grubs per sq. ft.

		Plots and treatment in pounds										
		1/8		1/4		1/2		3/4		1		
Date	Instar	1	2	3	4	5	6	7	8	9	10	Total
July 20	1	..	..	..	3	..	1	1	..	..	2	7
	2	..	..	..	..	..	..	..	..	..	..	0
	3	..	2	..	..	..	..	..	3	..	..	5
July 27	1	3	..	..	..	2	..	..	..	..	..	5
	2	..	..	..	..	..	..	..	..	..	..	0
	3	..	..	..	..	..	..	..	..	..	..	0
Aug. 4	1	..	2	2	3	1	12	..	14	..	3	37
	2	1	..	..	..	..	..	..	..	..	..	1
	3	..	1	..	..	..	..	..	..	..	..	1
Aug. 9	1	3	..	..	8	1	8	7	4	3	8	42
	2	..	..	..	..	..	..	..	..	..	..	0
	3	..	..	..	..	..	..	..	..	..	..	0
Aug. 17	1	7	..	..	2	8	10	11	5	14	7	64
	2	6	1	..	..	..	2	2	2	3	2	18
	3	..	..	..	..	..	..	..	..	..	..	0
Aug. 24	1	2	2	4	3	4	2	3	4	4	7	35
	2	1	1	1	1	1	3	5	3	1	2	19
	3	1	..	1	..	..	..	..	..	..	..	2
Aug. 30	1	17	1	..	..	6	1	..	4	..	4	33
	2	2	..	2	5	2	4	3	2	6	4	30
	3	..	..	..	..	..	..	..	..	..	..	0
Sept. 8	1	1	3	1	..	4	4	2	..	2	5	22
	2	1	4	4	..	3	5	5	6	6	5	39
	3	..	..	..	..	..	1	1	..	..	..	2
Sept. 20	1	3	9	1	..	1	..	8	..	1	..	23
	2	10	2	..	3	1	..	2	4	12	3	37
	3	..	..	..	..	..	..	..	4	2	..	6
Sept. 28	1	1	..	..	..	..	..	..	..	..	..	1
	2	6	..	..	..	6	3	4	8	3	2	32
	3	..	2	..	..	2	1	3	8	3	1	20
Oct. 20	1	..	..	..	..	..	..	..	..	..	..	0
	2	2	2	2	1	..	3	2	8	1	3	24
	3	1	1	1	..	..	1	5	4	2	..	15
Totals		68	33	19	29	42	61	64	83	63	58	

methods were used; however, in each case, the material was watered into the soil. In certain instances the first method was better, whereas in others the second method appeared to be superior. In any event, however, it is advisable to water the spore dust thoroughly into the soil after applying the material by a method best suiting one's own needs.

After July 11, 1944, a record was kept of the various instars and their relative abundance in all 10 experiments as well as the incidence of disease for each instar. Grub populations varied among the 10 plots. In some they were considerably higher than in others. The incidence of disease was highest in the plots having received the most spore dust. The average percentage of disease in the first instar was 37.4 per cent and, in the second instar, 39.8 per cent.

As the grub population developed during the summer, there was also an increase in the percentage of diseased grubs. When the peak of grub abundance was reached, a high point in incidence of disease was noted. Delay in development of the third instar and a preponderance of second instar grubs entering hibernation (virtually twice as many seconds as thirds, Table 16) can be attributed in part to an unprecedented dry season resulting in a considerable delay in beetle emergence and a two-week lag in attaining maximum abundance; also, to the slowness of development of the grubs in dry soil.

Winter Mortality

A study of mortality of Japanese beetle larvae during the winter was continued in 1943-44. Despite a lack of ground cover in the form of snow, considerable variation in grub mortality existed in areas of heavy beetle infestation in Connecticut. The winter of 1943-44, although not exceedingly cold, was month by month consistent in this respect. The mean monthly temperatures in the vicinity of New Haven for December, January and February were 29.2° F., 27.6° F., and 26.7° F., respectively. Snowfall for the entire winter in the vicinity of New Haven was 13.30 inches, none of which fell in December. From the 10th to the 31st of December, the average minimum air temperature for 18 days was +7.7° F. With the exception of the 13th, when a trace of snow was recorded, the ground was entirely free from snow during all of December. For 10 days in January, the minimum air temperature averaged +10° F. Snow cover was negligible throughout the month. During 15 days in February, the average minimum air temperature was +7.5° F. The amount of snow cover on 24 of the 29 days in the month was zero. The remaining five days of the month, however, had an average depth of snow of 3.06 inches during a period of average minimum temperature of +7.6° F. There were, however, 10 additional days in February having no snow cover, during which time the average minimum temperature was +7.4° F. It was found that, in the localities in which the survey was made and under the conditions noted, the average Japanese beetle grub mortality during the winter of 1943-44 was 16.7 per cent with a low of 2.5 and a high of 43 per cent. In the winter of 1942-43, having fewer days when the ground was not protected by snow, the average Japanese beetle grub mortality was 6.6 per cent. During the winter of 1944-45 when the ground was protected by snow for three months, the average grub mortality was 1.2 per cent. Soil temperatures at one-, three- and six-inch depths at Mount Carmel were above the lethal for Japanese beetle larvae all of the winter of 1944-45 with the exception of 60 hours during the first week of February.

A soil temperature of 15° F. is lethal to Japanese beetle grubs, and a fairly high mortality may be expected at 22° F. (1). Mail (2) and Fox (1) have shown that there is a considerable lag in the attainment of low soil temperatures as the air temperature drops, and this becomes greater as the distance below the soil surface increases. Moreover, even a light snow cover has a definite insulating effect. The observations recorded above indicate that no extreme mortality of grubs will occur over any wide area at the air temperatures experienced and that snow cover definitely influences the effect of low air temperatures.

Insect Parasites

A comparison of *Tiphia vernalis* cocoon populations with Japanese beetle grub populations in areas in which the parasite had been colonized showed that at 55 colonization sites representing 53.9 per cent of the total colonies in the State, Tiphia cocoons were present in 21 or 38 per cent of them. There appeared to be no significant difference between the average Japanese beetle grub populations per square foot of soil on the basis of year of parasite release. Apart from that, however, there was a marked difference between the number of Japanese beetle grubs in relation to the number of Tiphia cocoons in the same diggings. The older colony sites such as 1936 and 1938 show a considerably greater proportion of Tiphia cocoons to Japanese beetle grubs in the soil than the more recent (1942) colony sites.

Scouting for adults of *Tiphia vernalis* and *T. popilliavora* enabled us to see that the spring Tiphia, the former of the two species, had survived in large numbers in several localities in Bridgeport, New Haven and Hartford. Males were extremely abundant for one week during the middle of May. Prior to that time, a few were found on each occasion the localities were visited. After the 17th of May, few or no male wasps were seen and the decline of this sex was noticeably rapid. Females were extremely difficult to find and none was seen until the last day of May. Failure to find females may have been due to a lapse of a few days in scouting. Owing to the parasite's dependence on exact weather conditions for activity and the shortness of time during which it may be found, collecting is more or less of a gamble, especially so when, by necessity, limitation was placed on frequency of visits to colony sites.

Tiphia popilliavora, commonly known as the summer or fall Tiphia, is well established in a number of localities, displaying wide distribution in several of the principal Japanese beetle infested areas of the State. Up to 1944, a few of the colony sites were an abundant source of the species during the period of adult flight. This year (1944), however, owing to unprecedented dry weather, very few *T. popilliavora* could be found. Not only were the wasps somewhat delayed in emerging, but apparently many of them failed to leave the soil. With the exception of Seaside Park in Bridgeport, practically no wasps were observed at or collected from any of the colony sites in Connecticut.

Evidence of the survival of the tachinid parasite, *Centeter cinerea*, which attacks adult Japanese beetles, was obtained in early July, 1944. In Riverside Park in Hartford, beetles were found in large numbers feeding on wild evening primrose. A considerable proportion of them bore Centeter eggs. The number of eggs present indicated the attack was more than incidental. A number of beetles carried several eggs each, displaying further evidence that the parasite must have survived in considerable numbers from the previous year. It is quite possible the parasite is becoming better adjusted to its host in Connecticut, irrespective of abnormal conditions prevailing in 1944. If this be true, Centeter may perhaps in time play a part in the control of the Japanese beetle in this State.

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HIGH MEAN TEMPERATURES AS AFFECTING PLUM CURCULIO DAMAGE ON APPLES DURING THE PAST SEVEN YEARS

Philip Garman

It is well known that control of the plum curculio varies enormously from year to year in Connecticut apple orchards. As shown by Whitcomb[1], activity of the adult beetle increases as the temperature rises, and is so marked above 70 degrees that Massachusetts spray calendars have included the following recommendations: "Wait five days after 'Petal Fall Stage' and then apply (the spray) as soon as the maximum temperature reaches 75 degrees F. or higher and promises to reach that temperature on two successive days." It is interesting to observe that at Mount Carmel, Connecticut, during three of the seven years included in this study, mean temperatures above 70 degrees F. occurred within a week after the calyx or petal fall period (Figure 1). From our data it does not appear very probable that

[1] Mass. Agr. Expt. Sta., Bul. 285. 1932.

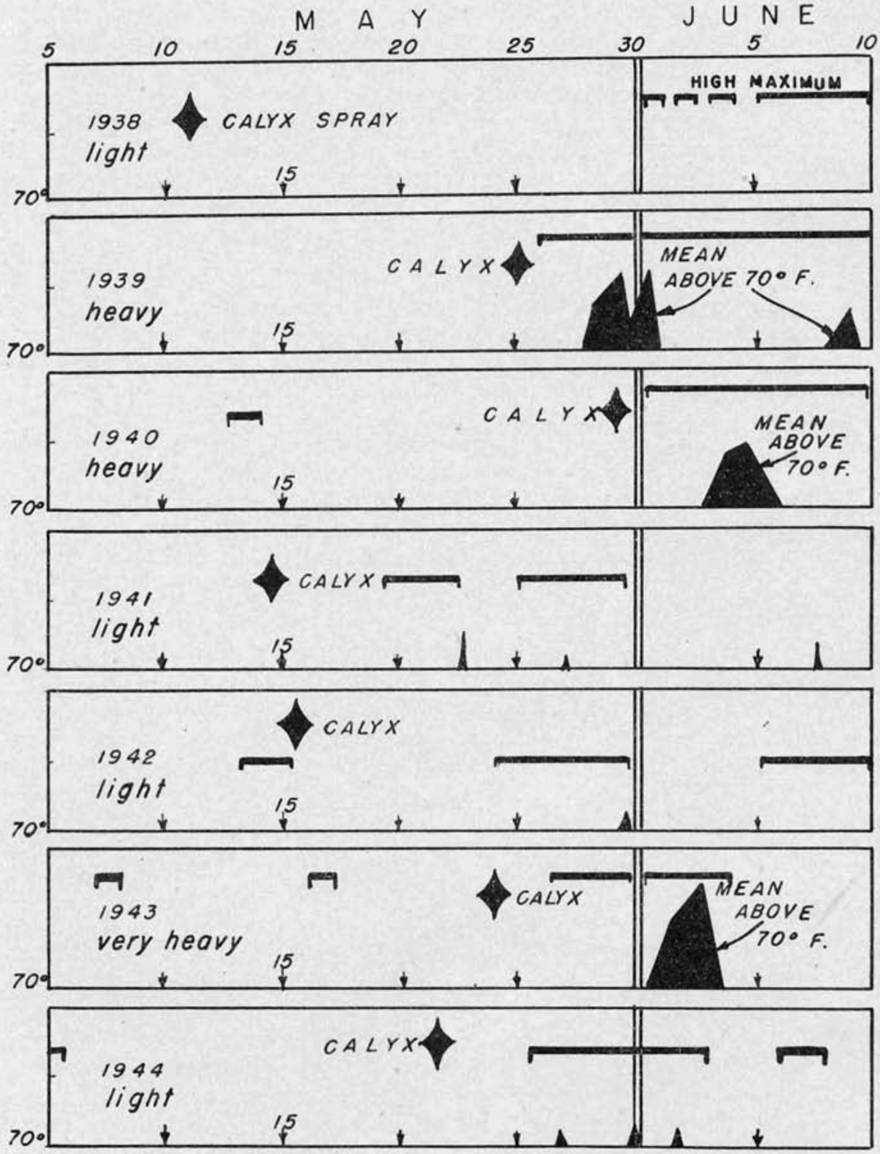

FIGURE 1. Temperature data in connection with curculio damage to apples at Mount Carmel. Diamond-shaped marks give dates of the calyx sprays. Periods when mean temperatures were above 70 degrees F. are shown in solid black; the heavy black lines show periods when the maximum temperatures reached 75 degrees F. or above.

high maximum temperatures immediately following calyx sprays necessarily spell a severe infestation for the year. Both 1941 and 1944 had periods of high maximum temperatures (75 or above) following petal fall within a week and yet the infestation generally appeared to be light in spite of varied spray programs.

Another factor of some importance influencing the severity of curculio damage to apples appears to be the temperatures prior to bloom. During two of the four years of light infestation, temperatures up to 75 degrees on two successive days occurred before bloom, and this is thought to have influenced the curculio in some way—possibly by bringing it from hibernation ahead of schedule and forcing it to seek other food. Thus, in 1944, one of the years in which this condition prevailed, curculio damage was light on apples but heavy on plums and peaches, indicating a trend away from the apples to a more favorite food.

These observations do not, of course, alter the advisability of applying sprays as recommended by the Massachusetts Station whenever the temperature reaches 75 degrees F. on two successive days, but it does suggest that for Connecticut, at least, mean temperatures above 70 degrees may be connected more intimately with serious damage to apples than heretofore suspected. It is also believed that high temperatures prior to bloom affect in some way the amount of damage to apples that may be expected.

THE EUROPEAN APPLE SAWFLY

PHILIP GARMAN and J. F. TOWNSEND

The European apple sawfly (*Hoplocampa testudinea* Klug) appeared in Connecticut apple orchards for the first time in destructive numbers during 1944. Specimens were received two years ago which are believed to have been the same insect, but we were not able at that time to trace the origin of the specimens or to find the pest in the field. This year, however, considerable damage was done to early apples in a Branford orchard and a partial survey showed the pest to be present from Guilford to Greenwich and back from the shore line for a distance of at least 10 miles. It was not found to extend further inland but may exist in localities not surveyed. Damage to at least seven different varieties of apples was seen in the course of the check-up, including commercial varieties such as Baldwin, McIntosh, Gravenstein and Cortland. Damage was most severe on early varieties such as Williams, Red Bird and Gravenstein. By chance, the worst commercial damage this year was to the variety Red Bird.

The apple sawfly is known to occur in western Europe, including Poland, Germany, Denmark and England. It has been carefully studied in England. In America it was discovered in central Long Island during 1939, but was also found in Victoria, British Columbia, in 1940. It probably has a much wider distribution in this country than is indicated by the reported discoveries.

Biology

The insect has been studied in considerable detail by Pyenson (4) who found only one generation a year on Long Island. Adults emerge early in spring about the time of the pink bud stage. They begin to lay eggs shortly after emergence, preferring bright, sunny days, according to several authors. If the weather is cool or cloudy, the sawflies spend the day hidden in the grass or other locations. Eggs are laid during full bloom or shortly thereafter and are placed within the calyx cup between the base of the stamens and the pistil. The young larva hatches directly into the calyx cup. The incubation period of the egg is eight to 15 days in England, 15 to 18 days in Poland and about a week on Long Island. The first stage larva usually mines the surface of the young apple, leaving identifying scars such as are shown in Figure 2. After the first molt, the black head and dorsal plates of the larva change to a brown color and the habits of the insect also change. It now begins to bore directly into the fruit and throws out a disgusting mass of brick red excrement (Figure 2). One larva may tunnel as many as six apples according to Pyenson, and it is abundantly clear from our limited observations that they often enter more than one. According to Pyenson and English observers, the change from one apple to another is usually made at night or on days when there is considerable moisture on the apples. Larvae leave the apples during June for pupation in the ground. In 1944, this was complete by June 20. Many apparently leave the apples at the time of the June drop. The larvae are said to penetrate the soil only a few inches (one to one and a half).

Control Measures

Owing to the habits of the apple sawfly, control measures must be applied early in the season in order to obtain satisfactory reduction of injury. Considerable emphasis is placed in the English literature on the use of nicotine combined with fungicides and spreaders. There is also mention of some benefit from the use of lead arsenate, but it is evident that the most effective controls were obtained there by use of nicotine or derris compounds. It is recommended by some that two applications be made in heavy infestations, but only one in case of a light infestation. If only one treatment is needed, it should be applied from three to eight days after petal fall. Some workers claim that the first spray should be put on when about three quarters of the petals have fallen. Pyenson, however, had some difficulty with the usual spray program for he remarks that "the standard calyx, curculio, and first cover sprays do not appear to hold the pest in check". Larval control measures should obviously be directed against the newly hatched larva from the time it escapes from the egg until the first molt when it begins to penetrate more deeply into the apple. Dusts

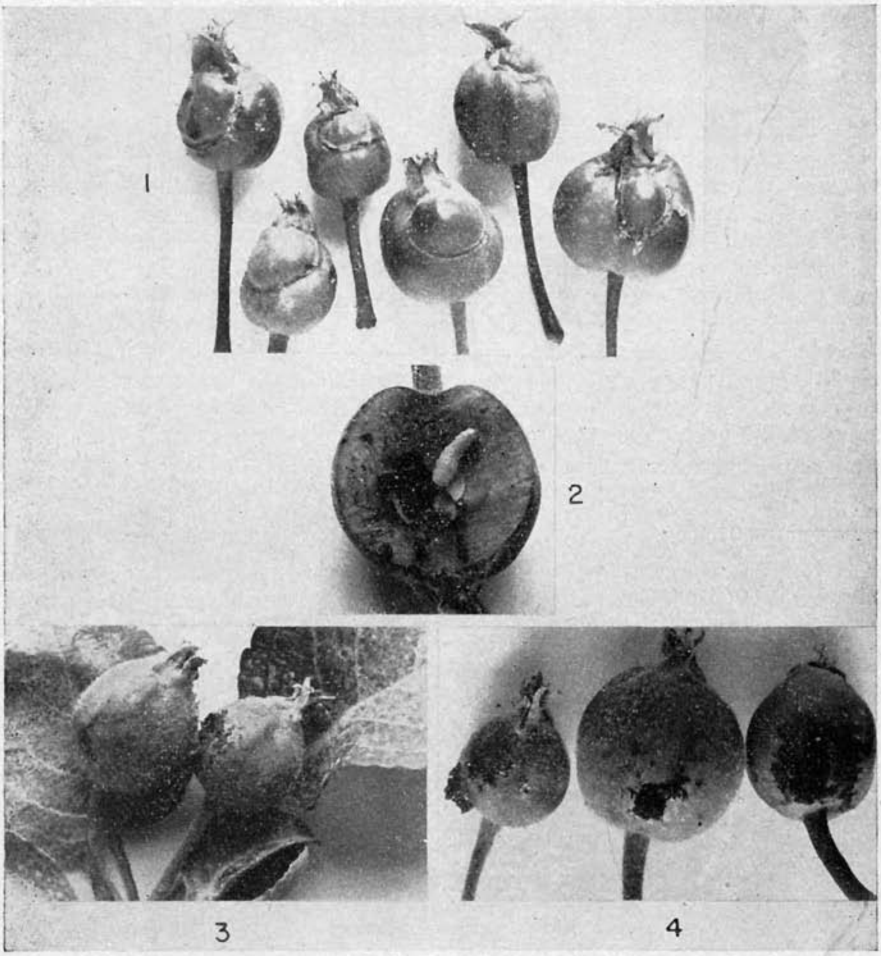

FIGURE 2. Work of the European apple sawfly, *Hoplocampa testudinea*. 1. Circular scars from early larval feeding. These scars are typical of the European sawfly. 2. An almost mature larva and its burrow. 3 and 4. Exit holes in young fruit. A single larva may infest several apples.

to kill or repel adults have apparently been used with some success, and insecticides applied to the fruit at the time of migration of the larvae from one apple to another cause some of the larvae to drop to the ground. They are then unable, according to reports, to crawl back up and resume feeding. Judging from our own limited observations, it appears that well sprayed trees in the vicinity of heavily infested ones developed no serious infestations. Furthermore, the worst infestations were found in orchards where one or more of the early sprays were neglected. We do not attempt to predict, however, what will happen when and if the sawfly infestation becomes more severe.

Possible Future Status

The apple sawfly may easily become injurious enough to cause considerable annoyance to the orchardists of Connecticut. However, because it has only one generation a year and because the larvae are easy to kill with various insecticides, control should not be too difficult. The fact that a single larva destroys more than one apple makes it a pest of real importance, and the reports of the rather high percentages of fruit destroyed in a single year make it look really serious. On the other hand, early blooming varieties are said to be more heavily infested than others, and the period of activity of the adult seems to be rather short compared with that of other insect pests of the apple. Whatever happens, it is clear that special emphasis will have to be placed on the pink, calyx, and first cover sprays and it may be necessary, as the insect becomes more abundant, to consider the regular addition of such materials as nicotine sulfate or derris to these sprays.

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WIREWORM INVESTIGATIONS

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Aside from the obvious facts that the eastern field wireworm, *Limonius agonus* Say, is a serious pest on sandy soils and that potatoes and tobacco, the principal crops grown on these soils in the Connecticut River Valley, are seriously injured at times, very little is known about this pest. We are gradually accumulating information which, when put together and supported by enough data, will enable us to understand better what is taking place. Some of the 1944 experimental work had to do with chemical control but greater emphasis was given to studying the habits of the wireworms in both the laboratory and the field.

Feeding

One of the most difficult things to understand is the feeding habits of wireworms, more specifically, the eastern field wireworm. The only pronounced and clear-cut feeding period on potatoes is that which occurs in early spring on the seedpieces. This usually lasts for one or two weeks, and the larvae leave about as suddenly as they appear. The rest of the season's feeding, that which is measured at harvest time on the mature tubers, is the net result of all the feeding attempts over a period of many weeks—from late July or early August to harvest time. The eastern field wireworm is not a heavy feeder, as other species are reported to be, and only a small percentage of larvae present in a hill of potatoes feed at any one time. In fact, larvae, kept in clay pots in which potatoes were growing, for experimental purposes, failed to feed at all on the tubers after the initial feeding period on the seedpieces. It is very common, from tuber-set up to about the time the tubers are an inch or two in diameter, to dig hills in which there are a dozen or more larvae present close to the tubers and yet to find no injury. The mere presence of larvae in the hill is no true indication that injury will result and that such injury will occur in proportion to the number of wireworms present. Feeding on tubers may or may not occur and those factors responsible for such irregularity remain undetermined. One of the aims of the 1944 experimental work was to determine the amount of injury attributable to varying populations and age groups. Larvae were collected from the field and confined in 12-inch clay pots in each of which a potato plant was growing. Unfortunately, the larvae fed little or not at all.

In general, it may be said that the wireworms feed heavily on the seedpieces and then go for a period of eight or 10 weeks without any obvious effort to feed further. Starting in mid-July, the larvae feed at random and over a period of many weeks. The per cent of tubers injured may be as great in August as in September or October but the degree of injury increases considerably during the same period, with the greatest injury occurring in early September. Injury counts made this year showed the per cent of tubers injured in August to be almost equal to that in October but by October the number of holes per tuber had increased from one or two holes to from six to twelve.

Injury Records

Injury records were again taken for potatoes on the green manure plots of the Agronomy Department, University of Connecticut. We now have data from the same plots for five consecutive years. Injury has increased somewhat each year so that it has gone from 10 or 15 per cent of the tubers in 1940 to approximately 75 per cent in 1944, for all plots. Population levels were not determined for these plots in 1940, 1941 and 1942, and only crude approximations were made in 1943 and 1944, but the increase in injury is believed not to be due to increased populations alone. This is based on population counts made in plots of a similar rotation study at the Tobacco Sub-station, Windsor.

Baiting

One of the most successful wireworm control methods in use today has for its objective the assembling of the wireworms to a suitable bait crop before the main crop is planted. When the wireworms are assembled to the bait crop, a soil fumigant is drilled alongside the bait row killing both the wireworms and the plants. After enough time has elapsed to allow the gas of the fumigant to escape from the soil, the main crop is planted. The success of such a practice depends largely on the number of larvae attracted to the bait. Field tests this year indicate that under our conditions wireworms will assemble to a bait, corn in this case, as early as the first week in May and in sufficient numbers to make the practice feasible. In view of the fact that this timing would delay our potato planting somewhat, greenhouse studies are now in progress to investigate the possibility of assembling wireworms to the bait rows first, planting potatoes between these rows and then treating the bait rows with a soil fumigant. Such a procedure would give greater freedom in the use of bait crops in conjunction with potatoes, as well as delaying fumigation until the soils become warmer.

Attempts to bait the larvae in the fall, after the potatoes were removed, showed that they do not respond to baits at this time of the year. Both corn and wheat were planted in late September on land which was heavily infested with wireworms but not a single worm came to the bait.

Wireworms can often be baited away from one crop to another which is a more desirable source of food. The Horticulture Department of the University of Connecticut has, for many years, been bothered with wireworms in their fertilizer experimental plots at the Coventry Farm. Tomatoes and peppers always became infested with wireworms, a dozen or more to a plant, and the plots had to be restocked several times. Since these plants were set out by hand, it was a simple matter to add a piece of potato (with the eyes removed) as each plant was set. This practice worked extremely well, and the plants had a chance to become established before the potato piece rotted, at which time the wireworms would come back to feed on the former. In home gardens, vegetable or flower, the potato pieces can easily be marked so that the potato, together with the worms that have come there to feed, can be removed by hand.

Chemical Control

Laboratory experiments were conducted to determine the toxicity of dichloro-diphenyl-trichloroethane (DDT) to larvae and adults. Because of the preliminary nature of these experiments, little can be said beyond the fact that DDT is not effective against the larval form but is toxic to the adults.

Both sprays and dusts containing DDT are toxic to the adults, and the symptoms of toxicity are apparent within a few hours after treatment. The sprays were made by dissolving DDT in deodorized kerosene and, although extremely effective at the dosages employed (2 and 4 grams pure DDT per 100 cc. kerosene), a practical use of this method of application remains to be determined. All dust treatments were made with Gesarol A Dust containing 3 per cent DDT.

Dust treatments were made on the soil surface since, in the absence of tobacco shade tents and other artificial constructions, the beetles spend all of their "life above ground" in close association with it. In these experiments, the soil in 12-inch clay pots was dusted and beetles subsequently caged over the treated soil. The rates of dust application, 50 and 100 pounds per acre, were chosen arbitrarily because they appeared to cover the soil adequately. In half of the pots the DDT was worked into the top inch of soil.

One hundred per cent kill was obtained in all cases. It is obvious that the lowest dosage required for minimum effectiveness was not determined but the fact that not a single beetle ever survived the treatment is encouraging. Experiments planned for the coming year will be designed to determine the practicability and effectiveness of this method of control under field conditions.

The effect of DDT on earthworms remains questionable. Most reports indicate that DDT is not toxic to earthworms, but greenhouse tests on a small scale, using 8-inch clay pots and only small numbers of earthworms, are not in agreement with these reports. When placed directly in a dust containing DDT, earthworms soon show its effects. They are not as active as untreated individuals and show extreme hypersensitivity when touched. When placed in water, to wash off the dust, the worms slough off a slimy film. According to other workers, the earthworms soon return to normal when placed in fresh soil. Apparently then, as a contact poison, the initial effects of DDT are soon overcome.

Earthworms potted in soil containing about 100 pounds of pure DDT per acre did not show this initial reaction. They behaved normally for 14 to 16 days and then began to show symptoms of toxicity. While the number of earthworms involved was extremely small (eight worms per pot), all those in the DDT pot died within a month while those in the check pot remained alive and healthy. Because of the slowness of the reaction, it appears likely that in this instance the DDT acted as a stomach poison.

Further greenhouse tests are now in progress to study the effects of DDT on earthworms when it is applied to the soil surface at the rates most likely to be used in the field. Other greenhouse tests are being made to determine if the potato plants, chiefly the tubers, will take up DDT under the same conditions of application and dosage.

DDT DUSTS IN DOSAGE TESTS ON VEGETABLE PESTS

Neely Turner

Dusts containing DDT (dichloro-diphenyl-trichloroethane) were compared in dosage series with materials ordinarily used to control the potato flea beetle, the potato leafhopper and the European corn borer. All dusts were applied as received from Geigy Company, Inc., and the series contained 0.5, 1.0, 2.0 and 4.0 per cent DDT. Dusts used for comparison were mixed in the laboratory using pyrophyllite as the diluent. All tests were made on small plots, replicated three or four times in randomized blocks.

Potato Flea Beetle

Newly-set tomato plants were dusted May 26 and June 3. Flea beetle attack was very destructive. Results were obtained by estimating the amount of feeding (Turner, 1943). The data are presented in Table 17 and dosage-response curves are shown in Figure 3. All concentrations of DDT were more effective than the most concentrated

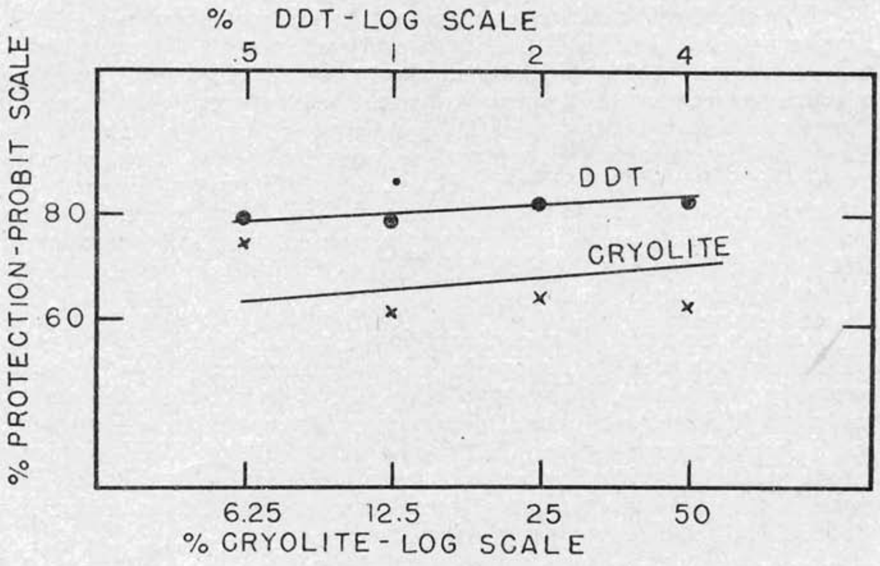

FIGURE 3. Dosage-response tests of DDT and cryolite dusts used to control flea beetles on newly-set tomato plants.

cryolite dust used (50 per cent). All DDT dusts caused a definite and striking chlorosis of the young leaves at the growing tips of the plants. The plants apparently outgrew the injury, but it could be found when the experiment was concluded on June 25.

TABLE 17. COMPARISON OF DDT AND CRYOLITE DUSTS ON TOMATOES TO CONTROL THE POTATO FLEA BEETLE

Material	Concentration	Per cent damage
DDT dust	4.0%	18.3
	2.0	18.3
	1.0	21.7
	0.5	21.7
Cryolite dust (pyrophyllite diluent)	50%	36.7
	25	35.0
	12 1/2	38.3
	6 1/4	25.0
No treatment		83.3

Irish Cobbler potatoes were dusted on May 26, June 2, 8 and 14. Flea beetles were moderately abundant. The damage was estimated on June 5. As far as flea beetles were concerned, the first two treatments were the only ones which might be expected to produce results.

The data have been tabulated in Table 18, with the yield per plant included and plotted in Figure 4. All concentrations of DDT were highly effective, and 1 per cent DDT produced as good results as 2 per cent rotenone in derris dust. The highest concentration of cryolite dust (50 per cent) was about as effective as 0.5 per cent DDT. Yields were somewhat variable, but in general DDT produced the highest yields, as would be expected from the pest control.

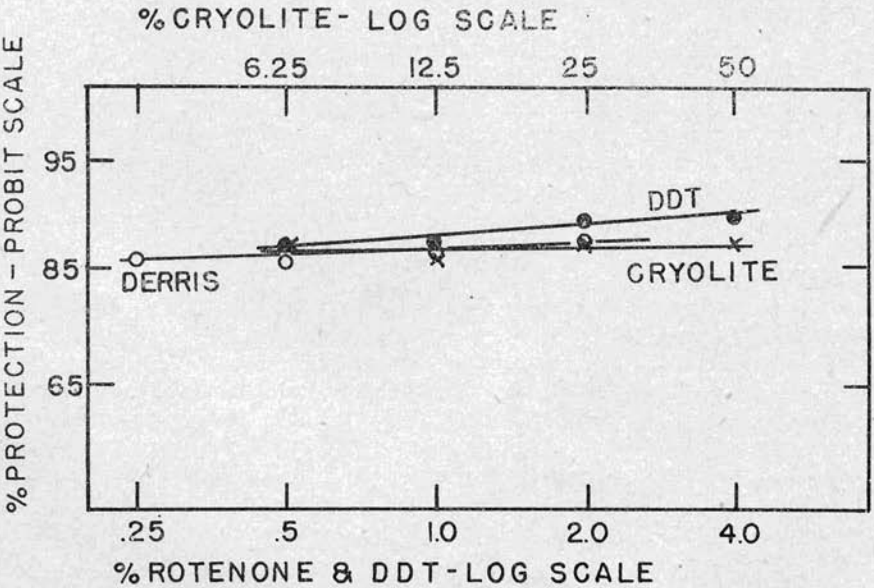

FIGURE 4. Dosage-response curves for per cent protection on Irish Cobbler potatoes from potato flea beetles.

TABLE 18. COMPARISON OF DDT, DERRIS AND CRYOLITE DUSTS (PYROPHYLLITE DILUENT) FOR CONTROL OF THE POTATO FLEA BEETLE

Material	Concentration	Per cent damage	Yield (grams per plant)
DDT dust	4.0%	9.0	350.9
	2.0	9.3	336.9
	1.0	11.3	272.9
	0.5	11.5	261.4
Derris dust	2.0% (rotenone)	11.3	287.8
	1.0	12.5	300.7
	0.5	14.0	250.9
	0.25	13.8	274.4
Cryolite dust	50%	11.8	308.4
	25	11.8	255.4
	12 1/2	13.5	244.1
	6 1/4	11.8	341.0
None		19.0	269.1

European Corn Borer

The potato plots described above were examined on July 12 for damage by larvae of the first generation of the corn borer, with the results listed in Table 19 and plotted in Figure 5. DDT was somewhat more effective than derris or cryolite.

Late sweet corn was dusted August 2, 7, 12 and 17 for control of the second generation of corn borer larvae. Results were obtained from August 21 to September 1 by dissecting 20 plants from each of the four replicates (Table 20). In general, DDT and derris compared much as in the potato experiment. Both were much more effective than nicotine-bentonite dust.

Potato Leafhopper

Green Mountain potatoes were dusted July 6, 18 and 25 and August 1, 15 and 22. The dusts were compared with Bordeaux mixture spray[1] applied on the same dates. The results are given in Table 21 and plotted in Figure 6 and show that DDT dust was much more effective in controlling leafhoppers and in reducing tipburn than Bordeaux mixture spray. In fact, 1 per cent DDT was equal to 4-2-50 Bordeaux mixture in tipburn control and much more effective than Bordeaux in leafhopper control. Yields were highly variable, but the DDT plots yielded as well if not better than those sprayed with Bordeaux mixture.

[1] This test was conducted in cooperation with the Department of Plant Pathology and Botany. Spraying was supervised by A. D. McDonnell and estimates of amount of tipburn were made by J. G. Horsfall.

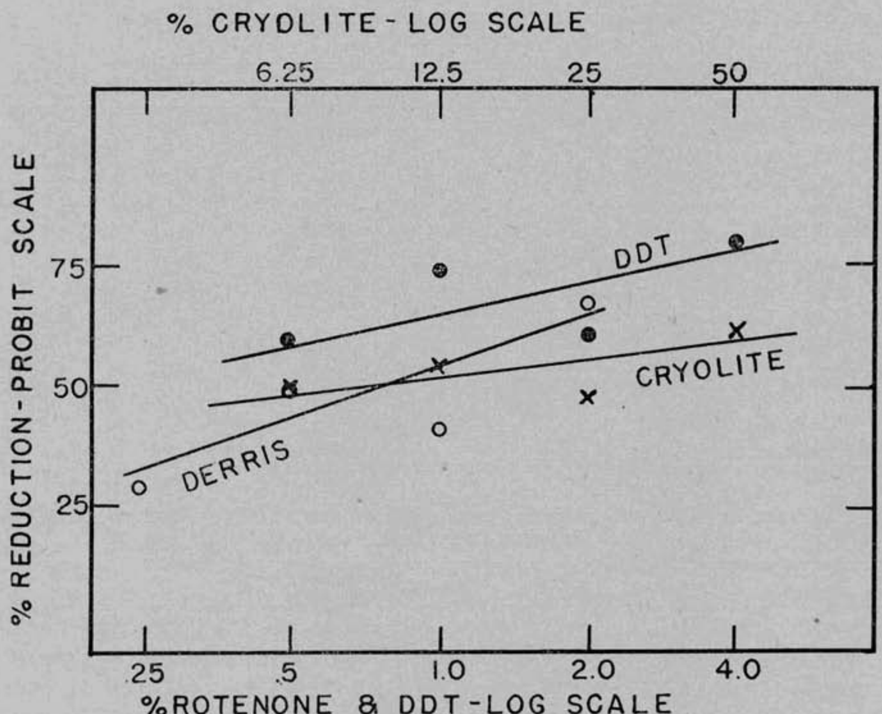

FIGURE 5. Dosage-response curves for reduction in damage by European corn borer on potatoes.

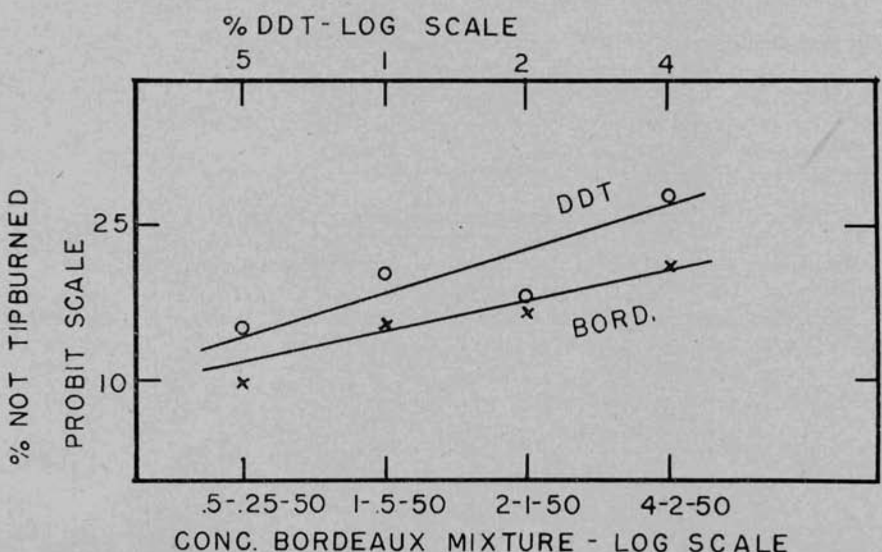

FIGURE 6. Dosage-response curves for protection of potatoes from tipburn.

Table 19. Control of Corn Borer on Potatoes Using DDT, Derris and Cryolite Dusts

Material	Concentration	Number injuries	Per cent reduction in injuries
DDT dust	4.0%	34	79.9
	2.0	64	62.1
	1.0	43	74.6
	0.5	66	61.0
Derris dust	2.0% (rotenone)	51	69.8
	1.0	100	40.8
	0.5	85	49.7
	0.25	120	29.0
Cryolite dust	50%	64	62.1
	25	88	47.9
	12 1/2	76	55.1
	6 1/4	86	49.2
No treatment		169	

Table 20. Control of Corn Borer on Corn Using DDT, Derris and Nicotine-Bentonite Dusts

Material	Concentration	Number larvae in 80 plants	Per cent reduction in larvae
DDT	4.0%	88	69.9
	2.0	126	56.8
	1.0	129	55.8
	0.5	174	40.4
Derris	2.0% (rotenone)	123	57.9
	1.0	135	53.7
	0.5	256	12.3
	0.25	170	41.8
Nicotine-bentonite	8% (nicotine)	139	52.4
	4	171	41.4
	2	218	25.3
	1	234	19.9
No treatment		292	

Table 21. Control of Leafhoppers on Potatoes with DDT Dust and Bordeaux Mixture Spray

Material	Concen-tration	Number leafhopper nymphs Aug. 2	Per cent reduction in leafhoppers	Per cent tipburn Aug. 13	Yield (grams per plant)
DDT dust	4.0%	7	81.5	59.1	331
	2.0	9	76.3	79.2	248
	1.0	15	60.5	74.3	277
	0.5	6	84.2	83.6	189
Bordeaux spray	4-2-50	26	31.6	73.8	275
	2-1-50	32	15.8	81.5	253
	1-0.5-50	44	...	83.7	255
	0.5-0.25-50	55	...	90.6	178
Check		38		90.5	247

Discussion and Summary

In these field tests, the dosage-response curves for DDT dusts were very similar in slope to curves for other insecticides. In spite of the high toxicity of DDT, there was still very little difference in control as the doses used were doubled.

In many tests, the results were highly variable. Much of the heterogeneity was caused by an extreme drought which accentuated differences in soil depth and fertility and in some cases caused great variation in the distribution of insects. The curves as drawn represent a fair estimate of the average mortality to be expected. On the basis of these curves, DDT dust at 0.5 per cent was more toxic to potato flea beetles than 50 per cent cryolite. On the same pest, 0.5 per cent DDT was as effective as 2 per cent rotenone. For control of the corn borer attacking potatoes, 1 per cent DDT appeared to be as effective as 2 per cent rotenone. For prevention of tipburn on potatoes, 1 per cent DDT was as effective as 4-2-50 Bordeaux mixture but, from the curves, 2 per cent DDT should be about equal to 4-2-50 Bordeaux. In controlling leafhoppers, DDT was outstandingly more effective than Bordeaux mixture.

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USE OF DISODIUM ETHYLENE BIS DITHIOCARBAMATE (DITHANE) ON THE SOIL TO CONTROL INSECT PESTS OF PLANTS

NEELY TURNER

The classical example of controlling insects attacking plants by means of a chemical introduced through the root system has been the control of red spider by selenium. Hurd-Karrer and Poos (1) showed that insects died on plants growing in soil containing this chemical. Neiswander and Morris (3) and Morris, Neiswander and Sayre (2) introduced selenium salts into water, sand and soil cultures for the control of red spiders on a variety of plants and of aphids on chrysanthemums. When the concentration of selenium in the foliage reached 90 to 100 p.p.m., the red spider population was practically eliminated. Half this proportion was effective in controlling aphids on chrysanthemums.

The discovery that disodium ethylene bis dithiocarbamate (Dithane) applied in solution to the roots of bean plants killed larvae feeding on the foliage was made by entomologists of the Rohm and Haas Company in the spring of 1944. This water-soluble organic compound was developed as a fungicide for control of plant diseases. The fact that such a compound could be assimilated by plant roots and kill an insect feeding on foliage is of great importance. There are several practical ways of introducing such materials into plants. Moreover, the wealth of organic compounds which may be synthesized should contain materials toxic to insects and non-toxic to higher animals. For these reasons preliminary exploratory tests were made in the field during the 1944 season, using Dithane for control of some common pests.

Seed Treatment

Bountiful bean seeds were treated with Dithane, Spergon (chloranil) and Fermate (ferric dimethyl dithiocarbamate) at the rate of 0.125 per cent, 0.25 per cent, 0.5 per cent and 1.0 per cent (by weight). Counts of larvae of the Mexican bean beetle made on July 13 showed little evidence of substantial reduction in population of larvae per plant as compared with untreated checks. The 1 per cent concentration of Dithane, 0.25 per cent and 0.5 per cent Spergon and the 0.5 per cent Fermate showed populations smaller than on any check replicate. The largest reduction was only 35 per cent.

Solutions Applied to the Soil

Solutions of Dithane in concentrations of from 0.5 to four pounds in 100 gallons of water were applied in trenches along the rows of growing beans. The rate was one gallon to the 10 feet of row in the plot, there were three replications at random, and the treatment was made June 13. Counts of larvae on July 13 (Table 22) showed that the 4 per cent solution reduced the number of larvae in each replicate to less than the lowest check replicate, and that the total number of larvae on the plants treated with two and four pounds to 100 gallons was less than on the lowest check.

Irish Cobbler potatoes were treated on May 26, June 1 and June 14 in the same manner as outlined for beans. The amount of feeding done by flea beetles was estimated (Turner, 4) June 5, the amount of corn borer damage (Turner, 5) on July 12 and the percentage of leaves dead on June 11. The results are given in Table 23 in comparison with both Bordeaux mixture spray and cryolite dust. Dithane did not reduce substantially the amount of feeding by the overwintering flea beetles. Observation not supported by actual counts indicated that flea beetle adults feeding in July caused much less damage to

TABLE 22. SURVIVAL OF BEAN BEETLES ON PLANTS WATERED WITH DITHANE

Concentration	Number of larvae by replicates 1	2	3	Total
4.0 lbs.—100 gals.	143	44	136	323
2.0 " " "	65	198	91	354
1.0 " " "	204	172	171	547
0.5 " " "	128	296	551	975
None				
Check A	187	180	179	546
Check B	266	266	268	800

TABLE 23. EFFECT OF DITHANE WATERED ON IRISH COBBLER POTATOES AT THE RATE OF ONE PINT PER PLANT

Material	Concentration	Per cent flea beetle damage	Per cent control of corn borer	Per cent of foliage dead	Yield per plant (gms.)
Dithane	4.0 lbs.—100 gals.	16.0	4.8	15.6	246
	2.0 " " "	14.0	26.0	24.1	268
	1.0 " " "	19.5	33.7	23.8	258
	0.5 " " "	18.75	33.7	22.4	307
Bordeaux spray	16-8-100	10.5	0	27.3	246
	8-4-100	12.5	0	17.8	282
	4-2-100	16.3	0	22.4	263
	2-1-100	13.0	0	38.8	232
Cryolite dust	50%	11.8	62.1	18.8	308
	25	11.8	47.9	26.9	255
	12 1/2	13.5	55.1	34.5	244
	6 1/4	11.8	49.2	17.7	341
Check—no treatment		19.0	0	34.5	269

the Dithane plots than to untreated checks. With the exception of one concentration, Dithane reduced substantially the amount of damage caused by the corn borer. Moreover, the Dithane-treated plants had a smaller percentage of dead foliage than any of the other treatments. As far as yield was concerned, three of the four Dithane treatments yielded less than the check. However, the four Dithane treatments outyielded the four Bordeaux treatments. The apparent loss of yield as the concentration was increased might indicate that Dithane was injuring the plants.

Early sweet corn was treated with four pounds of Dithane in 100 gallons of water at the rate of 2 1/2 gallons to 10 plants. Treatment was made June 13, about one week after eggs had begun to hatch. Only 10 plants were treated, but a record was kept of the number of eggs hatching. Survival was determined by dissection of the plants July 7. The results are given in Table 24, with similar data for nicotine-bentonite dust treatment for comparison.

TABLE 24. CONTROL OF EUROPEAN CORN BORER IN EARLY SWEET CORN

Treatment	Number eggs hatched	Number larvae surviving	Per cent survival
Dithane	1,170	363	31.0
None	990	351	35.4
4% nicotine-bentonite	2,988	563	18.8
None	3,834	1,108	28.9

The data indicate a slightly lower survival of hatching larvae than in the accompanying untreated check, but nothing to compare with results of a standard dust treatment. It should be pointed out that treatment applied to potatoes, which started May 26, was more effective than treatment made on corn relatively later in the season.

Green Mountain potatoes were treated on June 29, July 17 and August 1, using four pounds Dithane in 100 gallons of water at the rate of one pint per plant. On July 18, there were 20 leafhopper nymphs on 40 leaves, while the check had 35 nymphs. On July 25, the treated had 19 nymphs and the check, 25. On August 2, there were 20 on the treated and 28 on the checks. Amount of tipburn was 33 per cent on the treated and 50 per cent on the check on August 4. On the same date, 4-2-50 Bordeaux mixture had 26 per cent tipburn. Yield of tubers of the treated plants was about 5 per cent less than the check.

Summary and Conclusions

Disodium ethylene bis dithiocarbamate (Dithane) applied as a seed treatment did not reduce the infestation of Mexican bean beetles to a marked degree. Watered on the soil, it resulted in noticeable reduction in population at the higher concentrations. On potatoes, substantial reduction in amount of corn borer damage was noted. Treatment of corn appeared to reduce slightly the percentage of survival of hatching larvae. Substantial control of leafhoppers and of tipburn was noted on late potatoes.

These exploratory tests indicated that the plants absorbed Dithane through the root system and transported it in some form to the stem and leaves, where it had some effect on insects infesting the plants. The fact that an organic compound acted in this manner offers a very interesting new field for exploration.

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EFFECT OF AN ALKALINE DILUENT ON CRYOLITE DUST

NEELY TURNER

The effect of mixing either acid or alkaline materials with cryolite was described by Marcovitch and Stanley (1). More recently Roark (2) has called attention to the necessity of using care in mixing insecticides, and especially acid and alkaline materials. Nevertheless, both talcs and clays are mentioned regularly in the literature as diluents for cryolite. Sometimes the same publications state that hydrated lime should not be used with cryolite. The pH of hydrated lime is about 12.0, and the talcs vary from 7.0 to 9.1. Obviously, a talc with a pH of 9.1 is less alkaline than hydrated lime.

In order to demonstrate the deleterious effect of an alkaline diluent on cryolite, two field tests were made. Early tomato plants were dusted with a dosage series of cryolite diluted with a pyrophyllite (pH 7.0) and a fibrous talc (pH 9.1). The materials were applied May 26 and June 3 for control of the potato flea beetle. There were three replicates, and each plot contained five plants. The amount of damage was estimated on June 7, and the results are summarized in Table 25. The variation was large in the pyrophyllite series but, on the basis of the data in the table, it is evident that cryolite-talc is much less toxic than cryolite-pyrophyllite. At best, 50 per cent cryolite-talc was not as toxic as 12 1/2 per cent cryolite-pyrophyllite.

A second test of the two dust mixtures was made to control larvae of the second generation of Mexican bean beetles. Dusts were applied to 20-foot plots replicated three times on August 9 and 21. Surviving larvae were counted August 25. The data are tabulated in Table 26.

TABLE 25. REDUCTION OF DAMAGE BY POTATO FLEA BEETLES ON TOMATOES USING CRYOLITE DUST

Conc. cryolite	Per cent not damaged with diluent: Pyrophyllite	Talc
50	63.3	55.0
25	65.0	43.3
12 1/2	61.7	48.3
6 1/4	75.0	38.3
None	16.7	16.7

TABLE 26. CONTROL OF MEXICAN BEAN BEETLES ON BEANS USING CRYOLITE DUST

Conc. cryolite	Per cent reduction in larvae—diluent: Pyrophyllite	Talc
50	100.0	95.5
25	85.1	67.2
12 1/2	49.2	65.7
6 1/4	73.1	64.2

On account of the extreme drought, the infestation was not uniform. However, in three of the four concentrations, pyrophyllite was by far the more effective diluent.

Summary

Cryolite-talc (pH 9.1) dust was substantially less effective than cryolite-pyrophyllite (pH 7.0) dust in controlling both potato flea beetles and Mexican bean beetles.

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CERTAIN EFFECTS OF DEFOLIATION OF DECIDUOUS TREES

PHILIP P. WALLACE

Defoliation of a tree results in complex disturbances throughout the structure of the plant. Some effects can be measured as changes in normal structural development, some can be described as alterations in the chemical composition of the plant, and certain effects are very difficult to describe in any accurate manner.

Effects of defoliation on the production of fruit and fruiting structures have been observed in some detail, but few studies of carefully planned, controlled experiments dealing with other precise effects of defoliation have come to our attention. The study of the chemical composition of cell sap and plant structures has provided some indications of the processes which may take place within the plant but there is a lack of agreement on many of the phenomena connected with defoliation. A recent and interesting approach to an analysis of the vigor of trees has been studied by Parr (14), in which voltage gradients of trees were found to be correlated with physiological condition. However, neither of these considerations are within the scope of this work.

The relation of defoliation to diameter increment and growth of forest trees has been widely reported and is discussed in texts. It is generally agreed (2, 6, 8, 12) that: 1. Outright killing of healthy trees by one defoliation is confined to conifers. (In view of the resistance of tamarack in the Northeast to almost perennial defoliation by the larch case bearer and the larch sawfly, this general statement should be restricted to evergreen conifers). 2. Frequent, repeated strippings of hardwoods severely injure and often kill them. 3. There is great variation in the effects of defoliation among species and within individuals of the same species. This is dependent on factors such as soil type, moisture supply, weather conditions, stand density, tree maturity and inherent characteristics.

Unquestionably, plant growth is regulated largely by the amount of food which the plant is able to synthesize and accumulate. Defoliation depletes the food supply and reduces growth of the entire tree due to the loss of sugars and starches present in the leaves, to the depletion of the stored carbohydrates in the stem and roots which are required for new shoot and leaf production, and to reduction of photosynthesis during the period while the leaf surface is reduced.

As pointed out by Heinicke (9), the first requirement for a good food supply in a healthy tree is a large, healthy leaf surface, well exposed to light. Furthermore, development of shoots and leaves cannot occur without food previously provided by the foliage.

The American elm, *Ulmus americana* L., is an important shade tree throughout much of the eastern United States, and although it is probably somewhat more resistant to adverse growing conditions and to defoliation than many species, the elm, in growth response and habit, is fairly representative of native deciduous trees in this region. This tree is particularly susceptible to attack by defoliators, and the two bark beetles, *Scolytus multistriatus* Marsh. and *Hylurgopinus rufipes* Eichh., as well as the weevils, *Magdalis* spp., are commonly found in the bark of elm. For these reasons, the elm has been employed here in studying certain effects of defoliation. The problem may be approached by the removal of a proportion of the total leaves, the removal of part of each leaf, gradual removal of the leaf surface, a number of complete defoliations or various combinations, but in this study many of the external evidences of response to one and two complete defoliations have been observed and recorded. The voluminous charts of measurements are mostly omitted from this discussion but they are summarized and have strictly guided the conclusions.

The terminology of Chandler (5) is used for convenience. The term "shoot" refers to growth of the current season while it still contains its leaves; after leaf fall, it is called a "twig". The term "vigor" is used to describe a condition of growth with shoots.

The Growth of Elm

Although some species of deciduous trees unquestionably commence radial growth in the trunk and limbs before the buds open in the spring, the wood cambium cells of elm become active only at some time shortly after the leaves have developed. The length of the period during which both radial and shoot growth continues varies with the age of the plant. Old trees have a very short period of growth and two-year plants may continue growth throughout the summer. The discussion of growth of fruit trees by Chandler (5) applies as well to the elm and to a great number of other deciduous trees. In the elms observed, radial growth was very largely completed by the middle of July and the final layers of narrow, thick-walled cells were usually formed by early September. There is little or no meristematic activity during the winter season, and approximately 95 per cent of the radial growth was formed from the middle of May to the middle of July. It is quite possible that defoliation in early June may affect the current radial increment but the greatest effect will not be apparent until the following season. Moreover, it has been shown (2, 12) that a reduction in annual increment as well as other effects of defoliation may be observed for several succeeding years.

The bud of elm is primarily a vegetative structure for, although the primordia of leaf and flower may be present within the bud, they are produced from a vegetative tip and do not arise directly from opening buds as occurs in many plants such as the Rosaceae.

The end bud and lateral buds near the end apparently inhibit the development of the other buds on the same shoot and nearer the trunk. This tendency is known as polarity, and accounts for the presence of lateral branches on current shoots only toward the tips under normal conditions. These develop near the end of the growth period. The next season's buds, located in the leaf axils, remain dormant unless affected by some severe physiological disturbance such as defoliation, mechanical injury or exceptionally favorable growing conditions. However, the effects of these disturbances on the plant are all subject to qualifications. If defoliation occurs before shoot growth is complete, growth continues from the tip but the other buds already formed remain dormant, and the foliage appears tufted at the ends of the branches. Defoliation after the end bud is formed stimulates the lateral buds as well as the end bud to produce new growth. The length of time during which this new growth continues is largely dependent on weather and soil moisture conditions. Although elm has no true terminal bud, secondary growth extends straight from the end bud without forming an angle and is generally distinguished only by ridges in the bark left by bud scales.

During the summer of 1943, branches of elm trees were periodically defoliated from the middle of June until the middle of September. New growth and refoliation occurred regularly until the last week in August when three of 10 branches failed to respond. From that time on, there was no further refoliation and most of the defoliated shoots died. Other trials in 1944 indicated that the buds of defoliated elm shoots consistently respond by producing new growth until sometime in late summer when treatment is ineffective and many shoots die.

It was clearly demonstrated that the formation of an end bud and cessation of shoot growth is very closely associated with the available soil moisture. The two-year-old potted elms used in defoliation tests were watered daily and continued growth until mid-August when the plants were inadvertently allowed to become quite dry. Shoot growth ceased and end buds formed within 72 hours. Continued watering did not cause the buds to open again during the season. Comparable plants which were not watered artificially ceased growth by the end of the first week in July.

The Development of Elm Leaves

The development of leaves of various species of plants has been studied (1, 7, 10, 13, and others) and it is known that most of the meristematic growth in leaves of deciduous trees takes place during the period when the bud is swelling and opening. Isanogle (10) found that cell division which increased the number of cell layers in leaves of *Cornus florida rubra* A., from that of the embryonic leaf to that of the mature leaf, occurred before the leaves were two cms. long. The great increase in size of leaves thereafter is due to cell expansion. If a piece of tissue is removed so that a hole is formed in the leaf blade, as commonly occurs from cankerworm feeding early in the season, the leaf may continue to expand to several times its original size. Neglecting a certain amount of dieback at the periphery, the cells constituting the border of the hole continue to expand as do those in the rest of the leaf, and the increase in area of the hole is proportional to the increase in area of the entire leaf. The shape of the hole may change, however, depending on its position in the leaf, since the direction of cell expansion may differ throughout the leaf. Therefore, the degree of injury which is caused by insects feeding on leaves of deciduous trees theoretically remains constant throughout the season as long as injury was insufficient to cause defoliation.

Experimental Procedure

Extreme variation in the degree of defoliation brought about by leaf-feeding insects in nature, even on adjoining trees, precludes the use of naturally occurring defoliation when precise information is desired. Even in woodlands which appear to be completely stripped by cankerworms or gypsy moth larvae there are often a few leaves, parts of leaves, or irregular midribs remaining. Occasionally, when geometrid larvae occur in extreme abundance, practically complete defoliation may occur before the larvae are mature. Some feeding has been observed in such localities on dormant buds of new shoots; the new green shoots themselves are sometimes fed on lightly. Moreover, the variation in effect of defoliation on growth of apparently similar trees makes well planned randomization essential. For these observations it was therefore necessary to defoliate the trees artifically. Since it is essential to control all the sources of variation possible, the gradual removal of the leaf surface of the experimental trees by insect feeding was prevented by protecting them throughout the season with sprays of lead arsenate and nicotine sulfate.

Preliminary tests of defoliating trees by spraying the foliage with various chemicals were entirely unsatisfactory. The principal difficulties are: 1. Materials which were effective in causing the leaves to drop were injurious to tender new growth and often to new buds. 2. When the concentration of chemical in the spray is lowered so that it is not obviously injurious to shoot growth, the leaves may die and turn brown without dropping. 3. There is a differential effect between trees and between parts of a tree, depending largely on vegetative development and exposure. 4. When leaves are killed but do not drop, development of dormant buds and subsequent refoliation is inhibited. In view of these difficulties, it was found necessary to remove the leaves by hand. They could not be pulled or stripped off because of injury to tender buds and new growth, but were cut off with the thumbnail or in some cases with scissors. The small portion of the petiole remaining quickly dries and drops off as in nursery budding.

Early in the spring of 1942, 48 elms, 1 1/2 to 1 7/8 inches in diameter and nine to 12 feet in height were planted, six by eight feet, at the Connecticut Agricultural Experiment Station Farm in Mount Carmel. The trees were fertilized and pruned lightly to encourage their establishment but injury during the very severe winter of 1942-43 made it necessary to eliminate six of the original trees. Since three treatments were included in the tests, the field was divided into 14 blocks of three trees each by commencing at one corner of the field, proceeding up and down the rows and placing the trees in groups of three as they occurred. Treatments were then randomized within the blocks, thereby making possible the segregation of error due to such factors as soil heterogeneity and variation in original size and vigor of the trees.

The trees which received one and two defoliations were defoliated at the time in early June when cankerworms were in the latter stages of development, and when some nearby unprotected elms were about completely defoliated. Leaves were again removed in late July from the 14 trees which received two defoliations at a time when the development of the larvae of the first brood of elm leaf beetle larvae corresponded to that of the cankerworms mentioned above.

In addition to the plot of elms described, observations were made of the total weight increment of 30 two-year-old potted elms defoliated in different ways. The elms to be potted were weighed with leaves attached and, at the end of the season after treatment, they were again weighed in the same condition. The trees for these treatments were numbered and chosen at random. While records do not indicate the actual gain in dry weight of these plants, they do supply accurate information on the relative effect of treatments.

During the summer of 1944, the same treatments were applied to the same trees in the established plot at Mount Carmel for a second time. After leaf drop in the fall, all the last two seasons' twig growth was removed and weighed. Other measurements in 1944 were taken as in 1943. The trends were all similar but much more pronounced.

Responses to Defoliation

Dieback

Graham (8) observed that the first parts of a tree to die as a result of defoliation are the extremities. The dieback which occurs in new shoots at the time of defoliation is probably due to excessive evaporation and failure of water to move into the shoots as it would normally. Unquestionably, dieback of defoliated new shoots is intensified by hot, dry weather. The extent of dying back of shoots and branches after refoliation appears to be governed by the reserve food supply of the tree as well as the available soil moisture.

Before treatment, all dead wood was pruned from the experimental trees. The total amount of dieback which occurred between the time of defoliation and the following May 1 has been recorded and is considered to be largely attributable to defoliation. In Table 27, the measurements have been divided into two classes: twigs of the current season and wood one or more years old. "Total growth" includes both live and dead wood of the current season.

TABLE 27. DIEBACK OF DEFOLIATED ELMS (In Inches). 1943

	Group Total			Mean per Tree			Dieback	
	Current Growth	1 yr. + wood	Total dieback	Current growth	1 yr. + wood	Tree total	Total growth	Per cent of total growth
Control	194	50	244	13.8	3.6	17.4	10,531	2.3
1 defol.	1,155	159	1,314	82.5	11.4	93.9	8,450	15.6
2 defol.	2,648	666	3,314	189.1	47.6	236.7	10,364	32.0

It is obvious without further analysis that: 1. The length of current growth which died greatly exceeded that of the wood one year and older in all treatments. 2. Dieback in the trees receiving one defoliation very much exceeded the control trees in both classes of wood, and the amount of dead wood of each class occurring in the twice defoliated trees greatly exceeded both of the other treatments. The following season the trunk, at least, was alive in all the trees in this series and all of them leafed out the next spring. In fact, only one tree died following two seasons in which the same treatments were applied.

Mean and Total Length of Current Growth

After leaf fall in October, 1943, the live current growth was measured on the 42 trees under treatment. Many new shoots which had developed after defoliation, as well as some of those defoliated, had died through part or all of their length. This is not included in the measurements below. When the adjusted mean twig lengths are compared, the mean for the trees defoliated once is found to be slightly greater than that of the controls, though not significantly so, but both are much greater than the mean twig length of the twice defoliated trees.

	Control	One defoliation	Two defoliations
Adjusted mean twig length	5.3266	6.1336	3.6334

TABLE 28. MEAN TWIG LENGTH. ANALYSIS OF VARIANCE

	Degrees of freedom	Mean reduced (Y^2)	F value
Between blocks	13	3.1441	.61
Control vs. treated	1	.0003	...
Control vs. 1 defoliation	1	9.4300	1.8
1 vs. 2 defoliations	1	43.3718	8.4**
Within blocks and treatments	25	5.1491	1

It is doubtful if the initial defoliation while shoot elongation is taking place stimulates shoots to grow any longer than they normally would; they are probably retarded. The slightly greater mean length of the twigs of the once defoliated trees is undoubtedly due to: 1. Failure of the longer shoots to produce as many laterals towards their ends as the controls did. 2. The death of some of the shorter, weaker shoots. The proportion of short shoots is, therefore, less in trees defoliated before the end bud is formed.

The mean total length of shoots produced per tree, adjusted on the basis of the proportion by which the previous season's growth for each group differed from the mean for all the trees, for the controls was 17.4 per cent greater than the mean for the three groups, one defoliation was 4.7 per cent below the mean, and two defoliations reduced total twig length 13.9 per cent below the mean.

Number of Living Twigs

One defoliation resulted in a decrease in the number of live twigs at the end of the growing season and two defoliations caused a substantial increase over both groups in number of twigs. The first defoliation occurred in early June, while shoot growth was generally still active. As mentioned above, following defoliation at such a period, growth continues as shoot elongation but the lateral buds in the axils of the leaves which have been removed remain dormant. Defoliation at a later period, such as the time of the second defoliation, usually stimulates many of these lateral buds into growth. The reduction in number of twigs following one defoliation as compared with the controls is due to dieback of the shoots and failure to produce as many laterals.

The number of twigs remaining alive at the end of the season following treatment has been adjusted for each group on the basis of the number produced during the previous year and is indicated below.

	Control	One defoliation	Two defoliations
Mean number of twigs	139	114	162
Per cent deviation from total mean	+.8	−17.8	+16.9

Diameter Increment

Since the length of the period of growth, both terminal and radial, decreases as trees grow older, until a time is reached at which very little growth is made and that small amount may occur within a period of two or three weeks, it is anticipated that a retardation of radial growth may be evident in young healthy elms, which were defoliated before cessation of growth, in that same season. Table 29 is a record of the radial increment of the three groups of trees from April, 1943 to April, 1944.

TABLE 29. DIAMETER INCREMENT IN MILLIMETERS. APRIL, 1943 TO APRIL, 1944

	Control	1 defoliation	2 defoliations
Group, total increment	64.5	15.0	19.5
Mean increment	4.60	1.07	1.42
Standard deviation	±2.37	.703	.712

When defoliation occurred during the period of radial growth, there was a marked decrease in radial increment for that season at the time of the first defoliation. A second defoliation later in the season after growth had practically ceased did not affect the radial increment for that season. As mentioned above, however, a greater reduction would be expected to occur in the twice defoliated trees during the succeeding years.

A microscopic examination of the wood structure of two-year branches from these trees, stained and mounted in glycerine, taken periodically throughout the summer, showed that, during the summer of 1943, the period in which 95 per cent of the radial growth took place extended from about the third week in May to the third week in July. During 1944, growth ceased a little earlier. There was no difference apparent in the physical structure of the growth rings of the trees in the three treatments, although it had been supposed that the renewed shoot growth subsequent to defoliation might be accompanied by renewed radial growth. The large cells of the early wood were fairly evenly interspersed with large vessels. These cells graded more or less gradually into smaller, thicker walled cells of late wood, containing the wavy bands of smaller vessels and there was no sharp demarcation evident to indicate an abrupt change in cell size and wall thickness, generally recognized as a false annual ring, which might correspond to the time of defoliation. Since this change in cell structure is reported to be not altogether rare (4: p. 158) and certainly occurs after the defoliation of some species of trees, it is possible that its failure to develop here was due to tree species, age, or growth conditions.

Kittredge (11) has recently demonstrated an interesting correlation between the amount of foliage borne by trees or stands and tree growth and size. He found a simple linear relation between the weight of foliage and basal area increment, and similarly with total volume increment. The regression of foliage weight on diameter was found to be linear when expressed in logarithmic units. However, when total leaf area (which is closely related to leaf weight) of the trees in these tests was plotted against diameter, no correlation was apparent for any of the groups. This may be due to early pruning, to the fact that the trees were only recently transplanted, or the differences in diameter between the trees may be too small to demonstrate a correlation with the foliage produced. In any case, these measurements do not invalidate the proposition that such trends exist nor reflect on the accuracy of this information.

Weight of Terminal Growth

In 1944, the 42 elms in the experimental field were again defoliated in the same manner as in the previous year. At the end of the season, all live twigs produced during the two years of treatment were removed and weighed. Severe mechanical injury to some of the trees restricted these measurements to five of the original randomized plots of three trees each, but the trend appears clear.

TABLE 30. TWIG WEIGHT (Grams). 1943 and 1944

	Control	1 defoliation	2 defoliations
Mean weight per tree	363.66	105.9	78.9
Standard deviation	298.7	29.94	20.98

The variation in twig weights was accentuated by the fact that one tree which was defoliated once each season died completely and one which was twice defoliated for two seasons lost all of the past three seasons' growth. In addition to this, there was considerable variability in the twig weights of the other trees. In no case did the weight of twigs of a tree once defoliated approach the maximum weight of the controls nor did the most vigorous of the twice defoliated approach the maximum of the once defoliated trees.

TABLE 31. ANALYSIS OF VARIANCE. TWIG WEIGHTS, 1943 AND 1944

	Degrees of freedom	Mean square	F value
Control vs. treated	1	245,273.3	7.2**
1 vs. 2 defoliations	1	1,822.0	. .
Within treatments	12	34,191.6	

It is not surprising that the weight of the twigs produced by the twice defoliated trees is not shown to be significantly less than the twig weight of those defoliated once. Although the mean length of twigs was less for the twice defoliated trees, the number of twigs was greater than the once defoliated and the diameter increment was about the same or slightly greater than the once defoliated. It is believed that the total effect of withdrawing large amounts of stored foods from the stem and roots to reproduce foliage may be much more serious to total twig weight when trees are defoliated twice each season than when leaves are removed only once, but if this is true more than two years of observation would be required to demonstrate it in this plot.

Number of Leaves

The mean number of leaves per tree at the end of the growing season is compared for each treatment. These totals are of general interest but they cannot be used as an indication of the photosynthetic possibilities of the trees. Even when adjusted for size, effective time, and other factors, a comparison would be biased because much of the chlorophyll in the older leaves had disappeared, margins were brown and curled, and these leaves presented a general bronzed appearance, indicating a poor physical and chemical condition for photosynthesis.

	Total leaves for group	Mean number per tree
Control	10,279	734
1 defoliation	4,998	357
2 defoliations	10,381	741

From observation of this data, it is obvious that the number of leaves present on the control trees was about the same as for the twice defoliated trees, and that one defoliation materially reduced the number of leaves per tree present at the end of the season. Transformation of these numbers to square roots and analysis substantiates these conclusions. It has been shown above that the once defoliated trees were treated at a time when the dormant buds were not stimulated to open and the leaves present at the end of the season were formed at the terminals on subsequent new growth. It is therefore expected that their number will be less than either of the other groups. Those trees twice defoliated produced more but shorter twigs and about the same number of leaves as the controls.

Leaf Size

The mean leaf area in square inches for each treatment was determined (16) in early September and the three treatments have been compared by analysis of variance as well as by their means and standard deviations which are presented below:

	Control	One defoliation	Two defoliations
Mean leaf area	3.4947	2.5213	1.1777
Standard deviation of mean	.9928	.8234	.4089

A substantial difference is evident between each treatment and, although the standard deviations are fairly large, an analysis of variance indicates that the difference within blocks does not approach significance. A marked decrease in the size of the new leaves occurred as a result of one defoliation and this decrease in leaf size was accentuated following two defoliations.

Date of Leafing

While Balch (3) was investigating the control of cankerworms on elm, he observed that the opening of buds and leafing was delayed in the spring following defoliation. Since the normal variation in time of leafing is so great among elms, it seemed advisable to examine the subject more fully. Therefore, in 1942, a plan was developed to evaluate first the effects of site, and of tree vigor, as indicated by the previous season's twig growth.

For this study, 36 elms, three to five inches in diameter, were selected during March. They were located in a fairly open, abandoned pasture where there had been very little foliage injury during the previous two years. Eighteen were tagged on a sandy hillside and 18 were marked for observation in swampland near a brook.

A standard system of scoring bud development was used throughout these tests. At the time when the most advanced buds had produced leaves one and one-half inches long, all the trees were rated with a score of "0" for tightly closed buds to "4" for those with the largest leaves. Apical dominance is not demonstrated in elm at the time of leafing; it is usually the center or lower portion of the crown where the buds open first and the most vigorous twigs in the top may often be delayed seven to 10 days. Therefore, the central section of the crown was considered in placing ratings.

When the development of buds of the trees on the warm, sandy hillside was compared with those growing in the swamp no significant difference was found (Table 32). This suggests that soil and, possibly, root conditions are of minor importance in the primary development of the buds, for the contrast of site was extreme. Studies of tree temperatures by Reynolds (15) substantiate this hypothesis, for it was found that, during cold weather, soil and water temperatures had little effect on the subcortical temperature of the trunk, nor did heat flow from the soil through the trunk in any important way.

The mean terminal length growth of the previous season's twigs was also determined and the trees were divided into two groups consisting of the 10 most vigorous elms and the 10 with the poorest growth. Although this was done without regard to location, both sites were almost equally represented. A consideration of the means and standard deviations for the observations in Table 32 demonstrates that tree vigor as indicated by the length of shoot growth did not appreciably affect the time of leafing.

TABLE 32. ELM LEAFING INDEX FOR SITE AND VIGOR

	N	Total score	Mean index	Standard deviation
Dry site	18	48	2.6	± .745
Wet site	18	42	2.3	.882
High vigor	10	30	3.0	.633
Low vigor	10	26	2.6	.800

The effect of defoliation on time of leafing was observed on the elms in the Station Farm experimental block from 1942 to 1944. The trees were scored as described above in the spring season previous to treatment, 1943, and the percentage by which each group deviated from the mean for all the trees was used as a correction factor for the ratings of the spring season following treatment, 1944. The results are summarized below.

TABLE 33. EFFECT OF DEFOLIATION ON TIME OF LEAFING IN SPRING

	Total score	Mean index	Standard deviation
Control	45.0	3.21	.877
1 defoliation	31.0	2.21	1.121
2 defoliations	17.0	1.21	.825

There is obviously considerable individual variation among these trees in time of leafing just as there was with the other groups discussed above. When the data are analyzed (Table 34), it is found that the variance between blocks is significant but in comparison the F value for differences between treatments is almost six times greater.

TABLE 34. ANALYSIS OF VARIANCE. EFFECT OF DEFOLIATION ON LEAFING INDEX

	Degrees of freedom	Mean square	F value
Between treatments	2	10.3035	23.07
Between blocks	13	1.8077	4.01
Within blocks and treatments	26	.4505	

Since the values used for rating were entirely arbitrary, the relative figures are more important than the absolute values of significance. The mean index very definitely demonstrates a retardation in the development of buds in the spring following one complete defoliation and this retardation was greater on the twice defoliated trees.

Bud Size

The buds developing on new growth subsequent to defoliation have not been measured nor studied in detail but general observations are very clear. Such buds after one defoliation are distinctly smaller than on normal trees and the size of the buds forming after two defoliations is still smaller. The obvious conclusion is that the total amount of stored carbohydrates is less in small buds, and this is reflected in the subsequent season's shoot growth.

Susceptibility to Attack by Bark Beetles

Due to the grave situation of the elms in the northeastern states brought about by the Dutch elm disease, there has been much publicity and general acceptance of the deduction that defoliation is a critical factor in the susceptibility of elms to attack by elm bark beetles, the vectors of this disease. Unfortunately, no careful observations on the subject are reported.

In these tests, 28 elms, one and one-half to two and one-half inches in diameter and nine to 15 feet in height, have been treated for two successive years. Fourteen were defoliated once during each season and 14 were defoliated twice. Only one of these trees died down to the ground and one died back to the trunk. The former was attacked by a few of each of the following species of beetles: *Chrysobothris femorata* Fabr., *Saperda tridentata* Oliv., *Neoclytus acuminatus* Fabr., and *Magdalis* spp. The tree which died back to the trunk was punctured by *Magdalis* adults but larvae failed to develop. None of the trees were attacked by elm bark beetles and the two trees mentioned were the only ones affected by other borers. Our experience indicates that these trees were sufficiently large to be infested if they had developed the physiological condition which is attractive to bark beetles. A source of emerging beetles was present within 100 yards, throughout the two seasons.

Other careful observations have been recorded for five elms, 12 to 15 inches D. B. H. It is known that these trees were completely defoliated by cankerworms during each of the past four years. For several years previous to that time, the foliage of these trees was severely injured but reports of their degree of defoliation are uncertain. The general visible effects of defoliation on these trees were similar to the experimental plot, but dieback was more severe, resulting in the death of numerous limbs from three to six inches in diameter. At the time of the final examination, no bark beetle galleries were found in the dead and dying limbs except in broken hangers and contiguous bark areas which in some cases were heavily infested with both species of elm bark beetles.

Although very little is known about the exact conditions of elm which attract bark beetles, it is apparent that defoliation does not ordinarily produce those changes which make elm material attractive for bark beetle breeding and suitable for the development of the larvae.

As a group, bark beetles differ in habits greatly among species; some attack live trees when their reduced vigor which attracts the beetles is not perceptible to man, and others require very different specific conditions associated with dying tree tissues. Therefore, the effects of defoliation on susceptibility to bark beetle attack may be expected to vary with the tree species affected.

Defoliation and Development of Dutch Elm Disease

A marked increase in susceptibility of elms to the development of Dutch elm disease has recently been demonstrated in controlled experiments and is discussed by Zentmyer and Wallace (17). The chemical and physical changes in the tree which make it more favorable for the development of the fungus have not been determined, but it is certain that defoliated elms which are infected with Dutch elm disease develop more extensive wilt and dieback, and greater discoloration of the phloem than normal trees.

Defoliation of Two-Year Elm Seedlings

It was believed that certain effects of defoliation might be more readily apparent on young plants, so a replicated series of treatments was applied to potted two-year elm seedlings placed in an open cold frame. The treatments were: 1. One-half of each leaf removed. 2. Every alternate leaf, or half of the total number of leaves removed. 3. One complete defoliation. 4. Control. At the time of defoliation, the fifth of July, all plants had ceased terminal growth and end buds had formed. Following defoliation, the plants were watered daily and growth commenced again on every plant and continued until the middle of August when they were inadvertently allowed to become very dry.

New growth on the completely defoliated plants developed from lateral and end buds but, on the plants with one-half leaf cut and on the controls, growth development was similar to that of the larger experimental control trees. On those plants from which half of the total number of leaves was removed, shoots developed from a few of the leafless lateral buds. These plants were weighed and measured before treatment and again in October. There was a wide variation in the increase in weight and total shoot length within treatments but the mean measurements suggested no differences between the treatments. In fact, the control trees made slightly less gain in both weight and length growth than did any other treatment. These tests with elm seedlings were only preliminary but the rather contradictory results are of value in suggesting that: 1. Young plants may respond to treatment much differently from large trees of the same species. 2. There is great variation in the response among individual plants which appear alike outwardly. In this case, heterogeneity in the growing conditions and soil was eliminated, so the causes for individual variation may be associated with inherent characteristics, character of roots and their size relative to the top, to the absolute or relative amounts of stored foods within the plant, or to perplexing combinations of many factors.

Summary

Certain effects of defoliation on the structure and growth of elms have been observed in an effort to clarify the influence of leaf-eating insects on deciduous shade trees. There is a wide variation in effect of defoliation among trees due to their inherent heterogeneity so that reliable information demands careful planning of tests, randomization and analysis of results. So many factors and so many interrelated effects are concerned that it is necessary to segregate and evaluate only a few of these in a limited study.

The growth and responses of elms are discussed as fairly representative of deciduous shade trees in the Northeast. Treatments here constituted one complete defoliation in early June, and two complete defoliations by removing the leaves again in mid-July.

Terminal dieback is one of the most noticeable effects of defoliation and this was more extensive on the twice defoliated trees. But after two successive years of treatment the trees appeared in fair condition and only one had died.

The mean twig length of trees defoliated once was slightly greater than the controls but two defoliations greatly reduced the mean twig length. However, the total twig length per tree was far greater for the controls and was successively less as defoliation was increased.

One defoliation brought about a decrease in the number of live twigs, while two defoliations resulted in a substantial increase over controls.

The mean total weight of the twigs of the control trees was three times that of those defoliated once and the weight of those twice defoliated was somewhat less than the latter.

Diameter increment for both groups of defoliated trees during the year following was about the same and approximately one-fourth that of the controls.

The number of leaves per tree produced after one defoliation was significantly less and the final number on the twice defoliated trees was about the same as the control. But defoliations successively reduced the mean size of the leaves as well as the mean tree leaf area.

Neither growing site nor tree vigor appeared to affect the date of leafing in the spring, but one defoliation caused a definite delay in the time of leafing, and this was further delayed by two defoliations.

Buds on the shoots formed after defoliation were smaller than normal and this is undoubtedly an important factor in the development of subsequent shoot growth from these buds.

Defoliation did not bring about the conditions in the test trees which make them susceptible to bark beetle attack nor did this occur in large trees observed for a four-year period.

Elms which have been defoliated are found to be more susceptible to the development of the Dutch elm disease than normal trees.

The response of two-year elm seedlings to defoliation was not significantly different from their controls, but the variation in shoot growth and in total weight increment within the groups of small plants was much more pronounced than with older trees, indicating marked hereditary influences while the plants are young.

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BIOLOGY AND CONTROL OF THE DOGWOOD BORER, Synanthedon scitula HARRIS

Philip P. Wallace

Introduction

The flowering dogwood, *Cornus florida* L., grows wild in the forests and is widely used as an ornamental tree in Connecticut. It is quite generally planted in suitable locations throughout the eastern United States from the provinces of Quebec and Ontario south to Florida and west to Minnesota and Texas (3). When the tree becomes eight to 10 years old, about the age for flowering, it is rather difficult to transplant and to establish satisfactorily. Unsightly callous growth is often produced on the trunk and limbs, flower buds may fail to develop completely, and the tree is relatively short-lived. One of the principal causes of these troubles is the dogwood borer, *Synanthedon scitula* Harris. The injury caused under the bark in the phloem and cambium regions of the tree by this borer is seldom recognized until damage is extensive. The control of various borers of ornamental trees has received attention (8, 12, 13, 18, 24) but the results of tests have varied and no generally satisfactory method of controlling the dogwood borer has been reported.

This borer is the larva of a clear-wing moth of the family Aegeriidae. Although its biology in Virginia has been studied (33), little is known of its biology in New England, nor of its control. The injury to pecan has been given attention for the past 40 years but, although in this case, the trunk and limbs are attacked, injury of economic importance is generally reported to be localized near newly-set buds, and this can be readily controlled (27).

The dogwood borer was originally described as *Aegeria scitula* by Harris in 1839 (14). In 1901, Beutenmüller (2) published a detailed description of the adults, and a description of the larva by Dyar (5), in his "Monograph of the Sesiidae". One of the earliest discussions of the biology and importance of this borer was given by Herrick in 1904 (15). Various other papers and texts dealing with pecan or shade tree pests mention *S. scitula* briefly (9, 10, 16, 21, 22, 28). The most recent comprehensive work on the clear-wing moths is that of Zukowski in 1936 (35).

The general use of two common names for this insect, the dogwood borer and the pecan tree borer, indicates that there is still some confusion concerning the identity of the borer which attacks pecan. Englehardt (7) speaks of *Synanthedon corrusca* Hy Edwards as a geographical race of *S. scitula* which seriously affects pecan, and reference is later made to this statement (33). However, the two have been well recognized as distinct species for many years. Although the larvae of several closely related species are quite similar in appearance and the nature of their injuries is alike, the adults are sufficiently distinct not to be confused. From the many records it appears that the dogwood borer, *Synanthedon scitula*, is primarily a pest of dogwoods in the northern states and also attacks pecan where this plant is present farther south. If this is true, there is little excuse for recognizing a separate geographical race and the two common names for *scitula* are synonymous. *Corrusca*, which attacks the same hosts, is much less common.

Distribution and Host Plants

Synanthedon scitula is native to America and is recorded from stations throughout the area where the flowering dogwood grows, from southeastern Canada to Florida and west to the Mississippi.

Although this insect is reported to have been collected from a large number of hardwoods among which are mentioned oak, chestnut, hickory, elm, willow and pecan, as well as from galls and excrescences, there may well be some confusion with at least two other species, *S. corrusca* Edwards and *Aegeria pyri* Harris. No attempt has been made here to determine the various hosts of the dogwood borer but it is significant that in the collection at this Station all the records are from flowering dogwood except one female recently reared from an oak gall, *Andricus punctatus* Bass. (Figure 7, C).

The genus *Cornus* is represented in this area by eight or nine species of shrubs or small trees, but the only species which has been reported to be attacked by this borer is *C. florida*. *Cornus kousa* is a small tree of Asiatic origin, very similar to *C. florida* in appearance and habit, and is planted as an attractive ornamental at least as far north as Boston. A careful examination of specimens in southwestern

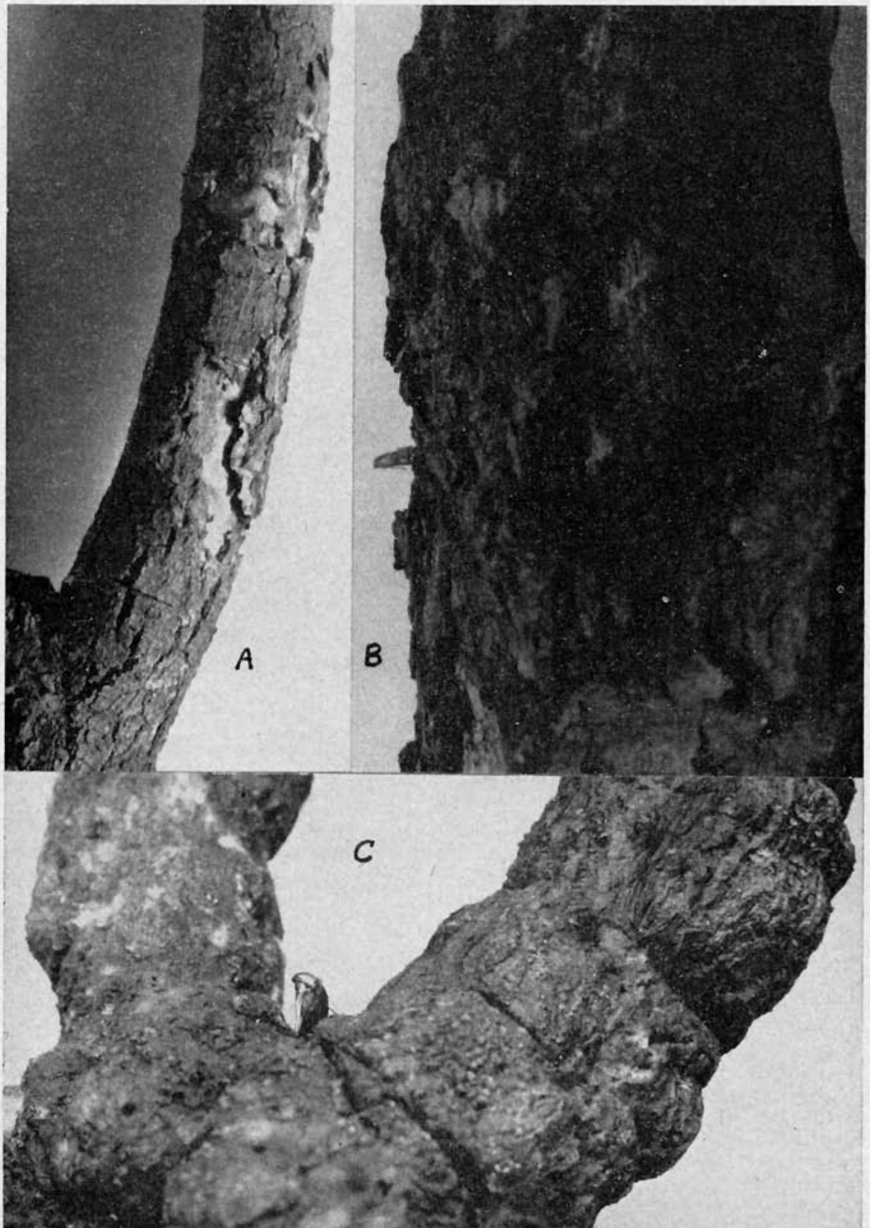

FIGURE 7. *S. scitula.* A. Injury to dogwood limb. B. Protruding pupal skin. C. *A. punctatus* gall on oak with pupal skin.

Connecticut and the reports of nurserymen indicate that this species is uncommon and has not been seriously attacked here by the dogwood borer.

Systematic Position

When Harris in 1839 (14) described this moth, he placed it in the genus *Aegeria*, of the family Aegeriidae, and it remained so classified as *Aegeria scitula* for several years. Although Say in 1869 (30) did not refer to this species, he mentioned that the genus *Aegeria* was erected by Fabricius for the reception of such species of the genus *Sesia* as have the palpi prominent, distinct, and covered by elongated scales. In Smith's List (31) published in 1903, this species is placed in the genus *Sesia* of the family Sesiidae and the name Aegeriidae is dropped. In Beutenmüller's Monograph (2), published in 1901, and in Dyar's List published in 1902 (6), the name *Sesia scitula* was accepted. However, Holland in 1903 (17) after careful consideration, expressed regret for the necessity of a change in the entire classification of the species. He found that the name *Sesia* is strictly applicable to a genus of the Sphingidae, and according to the laws of priority the family name Sesiidae must yield to the name Aegeriidae. Holland then applied to the genus the name *Synanthedon*, proposed by Hübner. That this was a proper and logical procedure, as he observed, is substantiated by the acceptance of *Synanthedon scitula* Harris (= *gallivorum* Westw., = *hospes* Walsh, = *aemula* Hy Edwards) by later specialists as Barnes and McDunnough (1), McDunnough (23), and Zukowski (35).

Description

Adult

The adult of the dogwood borer is a clear-winged moth having narrow, transparent wings, and a general iridescent blue-black color with yellow markings. Beutenmüller (2) has ably described the adults and this description is quoted below.

Sesia scitula (Harris)

"**Male.**—Head and antennae black; palpi yellow, tip black; orbits white. Thorax deep blue black with a yellow line on each side and a yellow patch on each side beneath. Abdomen deep blue black with a narrow yellow ring on the second and fourth segments, the latter covering the whole segment beneath. Anal tuft black. At the base of the abdomen is a yellow line reaching to the end of the second segment. Femora blue black, tibiae yellow with a purple band on the middle and hind femora. Anterior coxae yellow. Fore wings transparent, borders and discal mark blue black, narrow; outer margin broad, with yellow rays. Underside brighter than the upper. Hind wings transparent, margins very narrow, blue black.

"**Female.**—Similar to the male, but heavier. The palpi are wholly yellow and the fourth segment is yellow above and below; the fifth and sixth are yellow beneath; on the fore wings the yellow between the veins of the outer border is more distinct and the anal tuft is yellow at the sides.

"Expanse: Male and female, 18-22 mm.

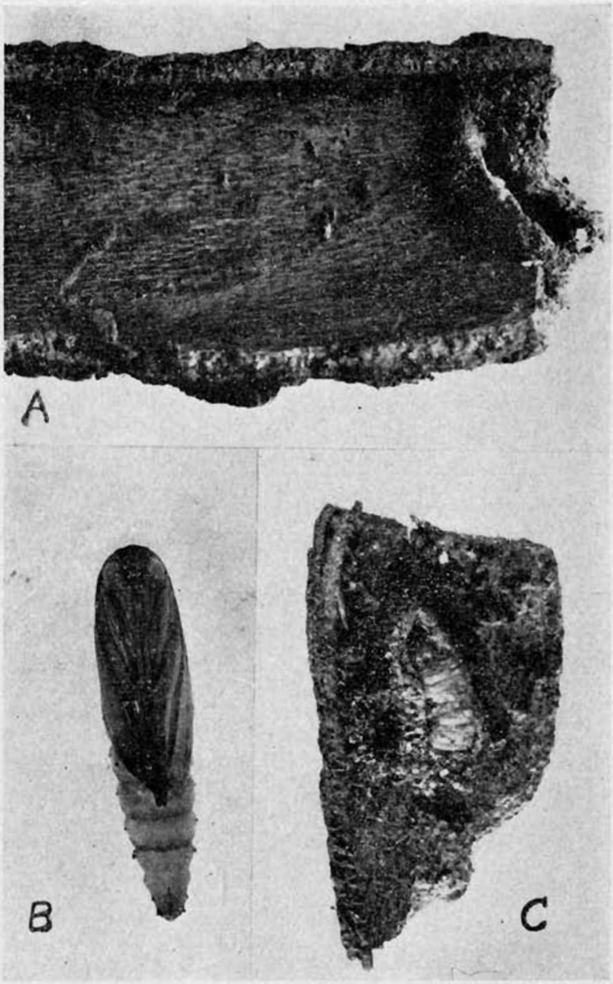

FIGURE 8. *S. scitula.* A. Pupa case. B. Pupa. C. Prepupa in case.

"**Habitat.**—Canada, New England, and Middle States, to Virginia, westward to Ohio and Illinois.

"Types: One female. Coll. T. W. Harris, Boston Soc. Nat. Hist. *Aegeria aemula,* male and female. Coll. U. S. Nat. Mus.

"**Larva.**—'Head normal, lobes meeting in a point, paraclypeal pieces narrowed centrally and rounded above, slight impressions centrally and toward apex; pale brown, dark about the mouth, epistoma colorless, a pale area above the paraclypeus, clypeal sutures dark. Body scarcely annulate, but the second annulet (tubercle ii) apparently the highest; subventral folds distinct; spiracles small, brown ringed. Crochets 12 to 15 in a row, distinct, normal though fine and small on account of the small size of the larva. Lower posterior ocellus pale, without pigment spot, but with a weak lens. White, a dark vascular dorsal line centrally; cervical shield membranous with brown curved lines at the corners. Joint 13 normal, divided into two segments, the posterior one small.' (Dyar, MS.)

"Closely allied to *Sesia pyri,* but the legs are largely yellow; the thorax has a yellow stripe on each side; the antennae lack the white patch and the female has the fourth segment wholly yellow above and below."

A more recent description by Zukowski (35) differs from the above principally in word usage.

In addition to this description, certain other characters are noted which may assist in the identification of this species and the separation of the sexes: At the base of the head, dorsally and extending laterally almost to the ventral surface, is a collar of stiff hairs, yellow dorsally, becoming white laterally around the base of the eyes. In both sexes, the ring of yellow scales on the second segment of the abdomen extends slightly below the mid-line laterally and is absent on the

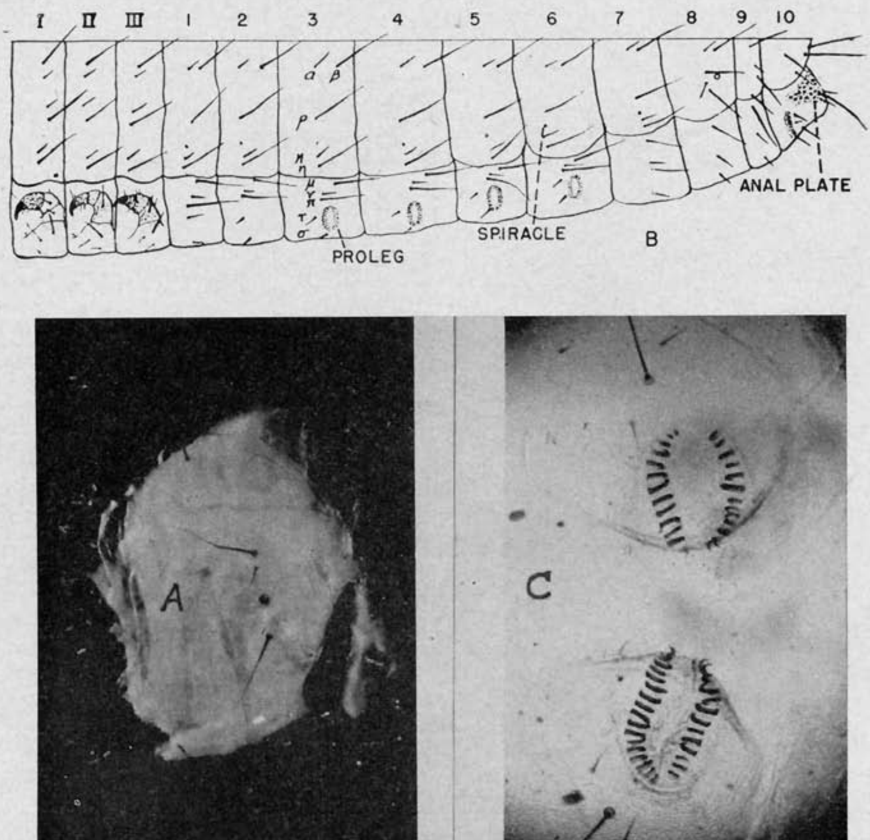

FIGURE 9. *S. scitula.* A. Spiracle. B. Schematic lateral view of larva. C. Abdominal prolegs.

ventral surface. The anal tuft is fan-shaped in the female and brush-like in the male. Killed specimens which are kept for some time without special treatment become oily so that the color pattern and other characters are best observed directly after mounting.

Egg

The egg is light chestnut brown in color. It is shaped somewhat like a hen's egg, slightly wider at one end than the other and flattened on the wide end. The surface is minutely marked with fine, barely elevated lines, forming hexagonal figures. The egg is about 0.6 mm. in length and 0.4 mm. in width.

Larva

The larva is whitish to light cream in color with head and prothoracic shield brown. In the later instars rounded spots of darkly colored cuticle are visible in the yellowish, chitinized area on the dorsal part of the last segment, the rudiments of the anal plate (Figure 9, B).

The head is well developed and on each side are six ocelli (Figure 10, C), of which the lower posterior ocellus is colorless. During the early instars, colored portions of the ocelli are shaped precisely as the hypothetical tear drop, but during development the pigmentation of the eye spots changes so that in the later stages the ocelli appear irregularly subcircular. Just before pupation this pigment has migrated completely, leaving the ocelli colorless. The two apicranial lobes of the head are rounded, and although Dyar (5) stated that the lobes meet in a point, they are contiguous for some distance (Figure 10, A). The adfrontal areas are narrowed above the center and rounded above and below so that the frontal sutures form sinuous lines. The triangular area between the lobes was recognized as the clypeus by Beutenmüller as early as 1901 (2: p. 227).

Near the base of the lightly chitinized prothoracic shield (Figure 10, A) are two darkened areas which vary in shape but appear, as suggested by Underhill, somewhat like golf clubs; often they are sickle shaped. This character occurs in other related species.

The 10 segments of the abdomen (Figure 9, B) and their folds are distinct, but they are sufficiently even as to appear hardly annulate. The second segment, however, is slightly elevated above the others. Prolegs are borne on the third, fourth, fifth, sixth and last segments, and each has a double row of transverse, uniordinal crochets (Figure 9, B), except the last segment which has a single row. There are nine to 14 short, recurved crochets in each row, with the outermost becoming gradually smaller. There are eight pairs of rounded spiracles (Figure 9, A) on the abdomen and one pair on the prothorax. They are small, sunken, and surrounded by a darkened ring. The size and relative position is similar on all segments except the eighth abdominal where the spiracle is conspicuously larger and

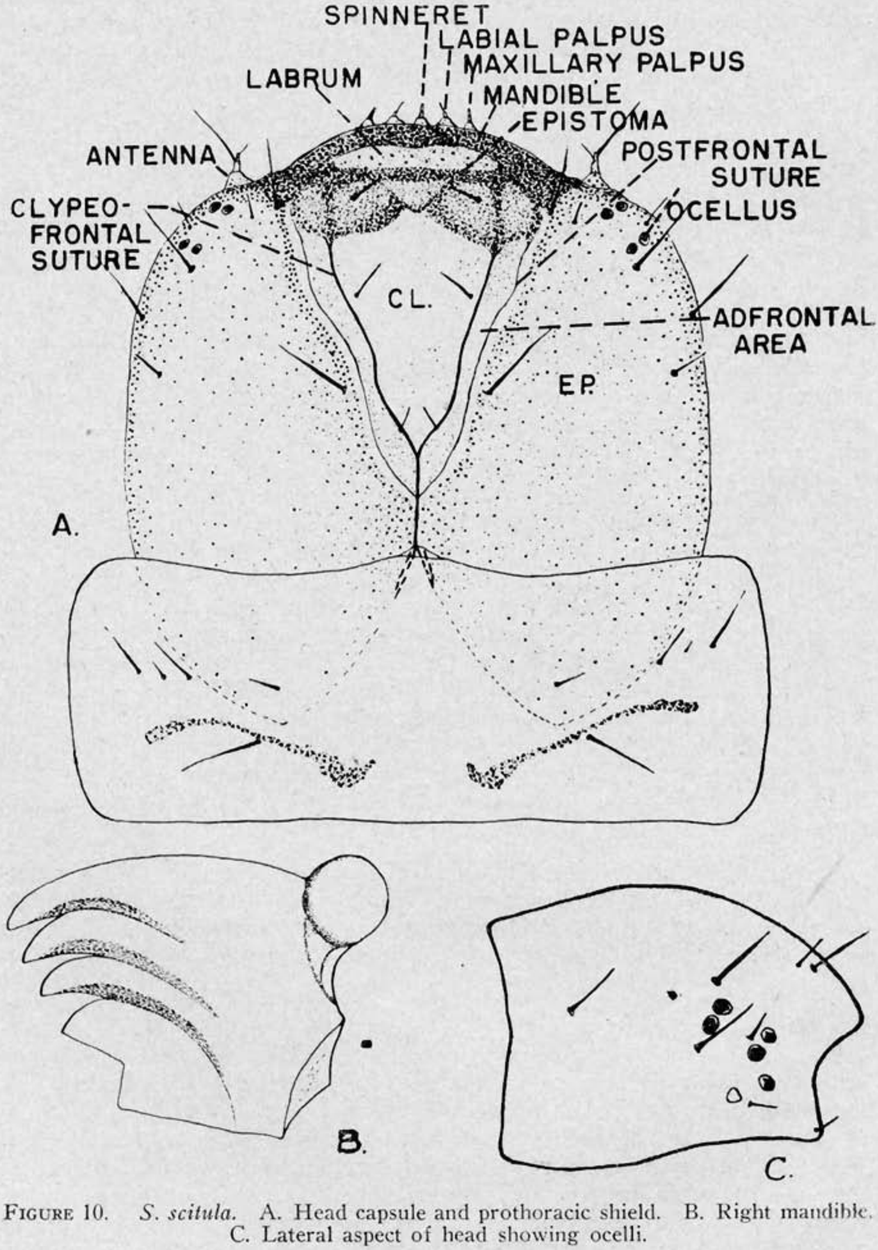

FIGURE 10. *S. scitula.* A. Head capsule and prothoracic shield. B. Right mandible. C. Lateral aspect of head showing ocelli.

located more dorsad. The setae (Figure 9, B) are much reduced, and according to Beutenmüller (2) they are arranged as in the Cossidae, Pyralidae and Tortricidae. In speaking of the identification of species of sesiid larvae he stated, "Several of them offer no tangible points of difference that I can obtain from the material before me", and we can readily agree with him.

Larval Instars

There is much difficulty in observing the consecutive molts of any larva which lives entirely within the bark and which is easily affected by moisture or food changes. Moreover, a great number of larvae of this type can seldom be obtained for measurement. The records presented consist of head capsule measurements of 47 specimens. Certain first and last instar head widths are the only ones which could be placed positively. According to Dyar (4), there is a constant numerical ratio between the head widths of successive instars of a larva, and a large group of measurements should indicate a definite break for each series. This is generally true in spite of certain disagreement. However, the number of measurements taken here may be insufficient, for they intergrade in so regular a succession that it is necessary in

TABLE 35. HEAD WIDTHS OF LARVAE OF *S. scitula* Harr. (measurements in millimeters)

	Instar I	Instar II	Instar III	Instar IV	Instar V	Instar VI
	.432	.533	.720	.972	1.152	1.353
	.432	.576	.756	1.008	1.180	1.404
	.461	.583	.792	1.094	1.181	1.440
			.828			
	.475	.590	.835	1.123	1.224	1.449
	.504	.590	.864		1.242	1.490
	.504	.612	.864		1.253	1.490
			.878		1.296	1.512
						1.573
						1.573
						1.584
						1.584
						1.656
						1.656
						1.656
						1.728
						1.728
						1.782
						1.800
Theoretical average	...	.599	.765	.978	1.249	1.596
Observed average	.469	.581	.814	1.049	1.218	1.581
Standard deviation	.030	.026	.061	.116	.050	.134
Greatest deviation from theoretical	.037	.031	.094	.077	.078	.228

some cases to select the limits more or less arbitrarily. This variation in head size of larvae known to be in the same instar may be due to nutritional factors. This is evidenced by the fact that larvae hibernate in almost all stages and the adults are active throughout the warm season. All measurements were made using a low power of a dissecting microscope. The head widths appear to fall into six groups as indicated by Underhill (33), although these could as easily be divided into several more groups. Considering the instars as six (Table 35), the ratio between instars is calculated to be 1.28.

Pupa

The cocoon (Figure 8, A) consists of brown frass loosely glued together on the surface with a mucilaginous material but more firmly cemented within. The inner lining is gray, tough silk. The cephalic end of the cocoon is more loosely constructed, which facilitates emergence. It is about 9 mm. in length and 4 mm. in thickness.

The prepupa (Figure 8, C), or latter part of the last larval instar, is characterized first by a light yellowish coloration, and quiescence. The body becomes shortened and somewhat humpbacked. When about to molt, wing buds and other changes characteristic of the pupa can be observed.

The pupa (Figure 8, B) is light brown in color, 5-9 mm. in length. On the dorsal part of the abdomen are 11 rows, or coronae, of short spines, triangular in shape and wide at the base. They extend laterally to a point a short distance below the spiracles and gradually become smaller toward the outside. The caudal segment is provided with eight stout spurs spaced evenly around the perimeter, the two on the ventral surface being slightly smaller and closer together. The empty pupal case is split from the head through the thorax on a mid-dorsal line.

Life History and Habits

Adult

There is one generation a year. The first moths emerge in this locality during the latter part of May and emergence continues throughout the summer until cool weather in September. Underhill (33) stated that the date of first emergence of adults in Virginia coincides closely with the first bloom of weigela Eva Rothke. It was interesting to observe in 1944 the first emergence of moths here on May 29, the day on which my weigela blossoms opened. The period of maximum emergence occurs during the last week of June and the first two weeks of July.

It is extraordinarily difficult to observe the activities of the moths for they are hard to see in the first place and move rapidly when in flight. Upon emergence, the adults remain near the cast pupal skin only a few minutes before flying away. They are easily disturbed at any time. Although a large number of moths emerged in a screened cage, six feet in all dimensions, mating could not be observed, and only one female was seen to deposit four eggs on the smooth trunk of a potted dogwood within the cage. These eggs did not hatch. When caged, the moths rested on the screening, seldom moving unless disturbed, and they were certainly not attracted to the two potted trees, except in the one case mentioned above. It is possible that eggs were deposited on the screening or framework, but minute inspection did not discover them. When two females and two males emerged in a large glass cage in the laboratory they behaved in the same manner as in the large outdoor cage, clinging for hours to the glass and occasionally flying to the opposite side, ignoring completely the dogwood logs in the cage. Peterson (25) found that wild males of *Sanninoidea exitiosa* Say were attracted from a considerable distance to caged females of the same species, but this did not occur here at any time with caged females of *S. scitula*. The four moths in the glass cage, two males and two females, all lived seven to eight days and, of four which could be carefully observed in the outdoor cage, one male and one female lived five days and the other pair six days. Underhill (33) found the average life of caged moths to be nine days for the female and seven days for the male.

Of 42 moths collected, 24 were females and 18 were males, but since the number is small the sex ratio may be about .50.

What little feeding the moths do is said to be restricted to the nectar of flowers. One adult female was seen resting on a blossom of apple but it disappeared without any feeding activity being observed.

Egg

The eggs observed in the cage and five others found on trees in the open were all laid singly but fairly close together. The four in the cage were located on smooth bark within two inches of each other and those in the field were all found singly and within two inches of a bark injury. They were on both smooth and roughened surfaces but none were found in the crevices between deep bark ridges, nor were any found directly on bark injuries. They undoubtedly are deposited there because Underhill found eggs more commonly on fresh cuts of caged logs than elsewhere. The average number of eggs which he observed deposited by 21 females was 38, with a maximum of 116. Hatching was not observed here, but the incubation period is said to be eight to nine days (33).

Larva

The small, newly hatched larvae have been seen in several instances, moving about over the surface of dogwood trunks. They travel rapidly and apparently aimlessly until they reach an opening in the bark. There is evidently no stimulus emanating from an injured bark area or calloused growth which affects the larvae, for a larva will approach quite close to a fresh bruise and then turn away abruptly. Considerable delicate manouvering was required to bring one larva to a suitable spot, but once there it commenced to tunnel in. In making such an excavation, the larva appears to discard the drier tissues and probably actually ingests only the more moist, inner portions of the bark.

The type of place in which these larvae are able to get a start and survive is quite distinct. A definite break in the bark is requisite; a roughened area alone is not sufficient, but the opening need not be so wide or deep that it is easily apparent to the unaided human eye. Moreover, somewhere about the injury there must be some kind of cover available. It may be a small piece of raised bark, the hole made by some other insect, or a crevice in which very little or no excavation is necessary to give the small borer immediate protection. In all the galls, calluses and injuries examined, it is apparent that the borers always reached the inner bark by way of some previous opening in the bark surface. A perfectly smooth bark tracing in which the edges do not dry and rise slightly is a poor location, but a good starting point is often available at the top or bottom of such a cut where the knife or chisel overran a trifle, or at the bark edges which have a tendency to rise while drying. This slight protection is of great importance. A large number of larvae have been transferred from trees and have developed normally on fresh logs, entering under a flap of raised bark, but it has been impossible to induce any larva to enter a fresh cut made like an axe blaze on a tree. If the edge were raised a bit with a knife point, the larva began a tunnel without delay.

The young larvae do not tunnel directly away from the starting point for a considerable distance as do many of the cerambycid and buprestid borers, but they destroy a large part of the nearby tissue with their irregular passage before moving on. Often the bark around a wound is riddled with the galleries of young larvae feeding close to the surface, giving the false impression that they entered directly through the bark. As the larva develops, the feeding tunnel is very much widened (Figure 7, A). It is customary to find most of the inner bark tissue eaten away over a large irregular area, leaving only the paper thin outer bark covering. At times, the larva may excavate irregular "dead-end" tunnels directly away from the main feeding area, but these are occupied for a relatively short time. When the thin outer bark covering dries out or an opening occurs for any other reason, frass is forced out of the exit with the caudal end of the body, and an accumulation is generally visible near the opening. This evidence of borer feeding may be entirely absent if the feeding is taking place distant from an opening or if the surface is broken. In either case, the tunnel is not kept clean nor is the frass tightly packed as with many borers. An accumulation of loose frass, silken threads, and bits of dry bark litter the whole excavation.

The spinnerets with which the larvae are equipped appear to be useful in forming threads to prevent dislodgment as well as for the construction of the pupal cell. A silken thread is secreted while the larva moves over the surface of the bark and these threads are also present in the tunnels. When a larva is removed from a tunnel, it often attaches itself to the nearest point with mucilaginous threads, and when placed in a Petri dish a large amount of silk is secreted wherever the larva crawls.

Larvae which are nearly mature at the time of hibernation often construct part or all of the cocoon and pass the winter therein. At this time or just before pupation in the spring or summer, the larva excavates a tunnel to the outer bark and there forms the pupal case, just beneath a thin layer of bark through which the pupa can easily penetrate to the outside. Occasionally, however, larvae leave their tunnels and form their cocoons in the trash or loose soil near the base of the tree. The cocoon is constructed with bits of frass and bark, held loosely together with the silky secretion.

Prepupa and Pupa

The prepupal and pupal stages are passed within the cocoon constructed by the mature larva, just under the bark surface (Figure 8, C, A). The length of time required between the completion of the pupal case and emergence of the adult varies considerably, and is largely dependent on temperature. The limits observed were 16 to 34 days and the average was 20 days for 14 records during 1944. External moisture in the atmosphere may affect emergence to some extent, but little is known about humidity requirements. The silken lining of the pupal case is good insulation and obviously assists in keeping the humidity within the cell at the proper level. If this lining is broken, the pupa quickly hardens and dies.

A few hours before completion of the pupal period, the pupa works its way upward with the aid of its abdominal bristles which grip the sides of the case. Here it breaks through the thin surface bark and extrudes itself as far as the third or fourth abdominal segment (Figure 7, B). The dorsal part of the head and thorax of the pupal skin splits on the middorsal line and the adult wriggles out.

Nature and Extent of Injury

The larvae of *S. scitula* feed on the inner bark of live, healthy dogwood trees. First instar larvae penetrate into the bark around injuries of any nature which have caused an opening and into cracked callus growths. In the earlier stages they feed in the outer portion of the inner bark, boring an irregular passage which becomes larger and extends almost to the sapwood after the second or third instar. Generally, attack is confined to the trunk and larger limbs, but borers and cast pupal skins are sometimes found at split or injured twig crotches. Occasionally the trunk is attacked at the ground level but evidence of attack to any part of the tree below ground has never been observed here.

Since *S. scitula* is particularly injurious to newly-set buds of pecan (15, 27), a special effort was made to determine if these larvae injure dogwoods in a similar manner, but no such damage has been found. At one large nursery in Connecticut, the dogwood stock is budded and, at another, it is grafted, but the managers report that over a period of many years they have never observed injury of this nature. In dogwood, attack is apparently confined to the trunk and limbs.

In a single year, one borer can completely girdle and kill a tree four inches in diameter, but death is more often brought about by the combined activity of several larvae and reinfestation for many successive years.

The conditions under which each tree is growing largely determine the severity of a given amount of borer feeding. If the thin layer of cambial cells, which are often not injured directly from feeding, is killed by drying out, large areas of bark may die at a considerable distance from the place of feeding. Often a vigorously growing tree can repair much of the borer injury in the current season, but such growth does not affect adversely the activities of the larva. There is no reason to believe that a dogwood borer can be forced out or killed by excessive sap flow or that it cannot keep ahead of the callus growth. Excessive callus formation about a wound suggests the presence of borers, and such growths appearing as gnarled cankers, are often enlarged as each year a new brood feeds a little farther out on the circumference.

The economic importance of the dogwood borer is probably underrated by commercial nurserymen and tree experts. This may be largely due to the obscure nature of early borer feeding and the presence of a complete fauna and flora which may greatly extend the original damage.

In this study, the dogwoods in eight nurseries were carefully observed, and the trees on several parks and estates were examined. In only one plot was the infestation negligible, and this planting consisted entirely of young stock isolated from wild dogwoods and large ornamentals. In six nurseries, over the period when the dogwoods had been held for sale, from 30 to 80 per cent of the original trees had died or become worthless to the trade as a direct result of boring by this insect. All of the owners were sure they had no dogwood borer damage of consequence. In ornamental plantings in southern Connecticut, 30 to 40 per cent of the large established trees are infested and replants nearby are quickly attacked. A large park planting near New Haven has been so severely affected that 20 per cent of the dogwoods planted three years ago have died and 40 per cent of the remaining trees have large dead bark areas and exposed wood surfaces. Highway plantings, particularly along forested areas, are quite severely injured and some extensive plantings are complete failures. This is due to the normal infestation of native dogwoods and to continuous injury to the bark from highway operations and traffic.

Underhill (33) reported that the infestation of forest dogwoods in Virginia is of little consequence, and a survey of several hundred forest trees indicates that only 2 to 3 per cent of this type of dogwood are infested in Connecticut. This is probably due to the occurrence of few bark injuries in this type of tree.

Natural Controlling Factors

Several larvae in all stages of development may inhabit the same locality, feeding at the edges of the original excavation, and no evidence of incompatibility has been observed. Although these larvae will kill and even devour others of the same species when closely confined, this is not evidence of true cannibalism, for such behavior is common with many non-cannibalistic species in artificial surroundings, particularly when crowded.

It is true that some galleries are very wet, but the larvae appear to thrive and arrange for sufficient drainage either by instinct or chance. While rearing larvae in cut logs, it was found necessary to change the logs and replace the larvae about every seven to eight days because they ceased feeding when the bark commenced to dry and later died. Under natural conditions, those larvae which are immature when the bark of a dogwood begins to dry die in their tunnels. Those in the last or penultimate instar usually develop satisfactorily. We have observed no attack by *S. scitula* to cut trees or limbs. When larvae are exposed to the atmosphere without protection they usually succumb within a few hours. The habit of local feeding and the failure of these larvae to kill outright many trees is apparently a biological phenomenon which serves to perpetuate the species. If the host dies prematurely, the insect cannot survive.

The occasional migration of a larva from one location to another on the same tree was noted in the insectary. This was also confirmed in the field when nearly mature larvae were found in short, new tunnels, distinct from any others. Where this occurred there was usually a well-developed and unoccupied tunnel from 6 inches to 2 1/2 feet away. This habit is probably rather common.

There is no precise information about the resistance to cold by larvae of *S. scitula* or any of the related species. It is known, however, that the range extends into southeastern Canada where winter temperatures of –20° to –30° F. are common. Moreover, there was no apparent reduction of the population following the winter of 1942-43 in sections of Connecticut where minimum temperatures reached –30° F. Although the larvae hibernate in the cortex, it has been shown that the insulating effect of the bark is of negligible importance in the mortality of larvae due to cold (34) and it appears that these larvae are well able to withstand extreme cold temperatures.

During the day, the subcortical layer of the trunk on the south side of exposed trees reaches a temperature which is often 5° to 10° C. higher than the surrounding air (shade) (19). Reynolds (29), working with sections of plant tissue, states that the subcortical temperature of living tree trunks never reaches a point high enough to be lethal to the cells of the cortex. He found that none of the cortical parenchyma cells were killed at 55° C., but all of them died when exposed for 30 minutes to 57° to 59° C., or for one minute to 65° to 69° C. Failure of the subcortical layer to reach such temperatures is due to the thermostatic cooling action in the tissues which partly or entirely counteracts the internal flow of heat. The lethal temperature for many bark-inhabiting insects is about 48° C. but certain heat-resistant forms, like *Chrysobothris*, can endure a short period of exposure to 52° C. (11). However, the highest air (shade) temperature on record for Connecticut is 105° F. (40.6° C.), and if the subcortical temperature exceeded this by 10° C. a maximum of 50.6° C. might be expected to have occurred under the bark. Some mortality of the larvae of *S. scitula* probably occurs in trunks that are exposed on the south side but the dogwood ordinarily produces a wide crown which shades the trunk. With these considerations, only an insignificant mortality of these larvae from solar heat would be anticipated at any time.

Larvae have been observed feeding during warm periods in March and December, and it appears that they remain inactive only when the trees are frozen or while temperatures are continuously low.

Notes concerning many species of the Aegeriidae fail to indicate cyclic periods of extreme abundance and scarcity. Although local intensification of the population in this study of *S. scitula* has been observed in small areas where the insect is established and conditions of the host become particularly favorable, it is apparent that during at least the past 10 years the general population in Connecticut has remained fairly constant.

Local differences in the degree of infestation among different areas of both forest and ornamental dogwoods is undoubtedly due to a combination of several factors, but these observations all indicate that the original establishment of the insect and occurrence of injuries to the bark are the most important considerations. Nearly all dogwoods at some stage in their life have openings in their bark suitable for borer entrance. Ornamental trees around parks or homes or roadways are much more susceptible to injuries of all kinds, even pruning cuts, and are more heavily infested. This high infestation is a greater liability to all new injuries. Practically all the aegeriids are light-loving insects and the moths are frequently found on flowers in the sun, but forest dogwoods suddenly exposed by cutting or situated at the edge of a clearing do not become more heavily infested than others unless they have received more bark injuries.

Dogwood bark is particularly thin and tender and many injuries are not noticeable. Unobserved damage often occurs while the trees are being planted or pruned. Serious borer attack may also follow bruises from a lawn mower or garden implements.

Many of those who have considered the subject have indicated that older, rough-barked trees, or roughened areas on younger trees are more frequently attacked. After carefully inspecting a great number of dogwoods this was found to be true, but there is also extensive evidence to indicate that the roughened areas mentioned are often a result of borer activity. The larvae always entered through a previous break in the bark with no evidence of discrimination against injuries on smooth-barked areas. One apparent reason for the higher infestation found in older trees is their added years of opportunities to become injured rather than the roughness of the bark.

Certain factors which affect the survival of the larvae have been mentioned and, although numerous observations have been recorded, no detailed study of the relation of parasites and predators to population density has been undertaken in this work.

Underhill (33) found that among natural enemies internal parasites were the most important in Virginia. He states that *Apanateles sesiae* Vier. is quite common, and in addition, from the larvae of S. *scitula*, he has reared *Microbracon sanninoideae* Gahan, *M. mellitor* Say, *Phaeogenes ater* Cress., *Scambus conquisitor* Say, and *Hyssopus sanninoideae* Gir. In this area, very few parasites have been observed or reared. Two species which have been reared here are *Ichneumon irritator* Fabr.[1] and *Amblyteles* sp. (near *vitalis* Cress.).[1] The larva of an unidentified species of clerid is found quite commonly in the larval tunnels of *S. scitula* in Connecticut, and in several instances when tunnels were opened this predator has been observed actively feeding on the borer larvae.

The small biting ant, *Crematogaster lineolatus* Say, is very commonly found in unoccupied tunnels of the dogwood borer. Appearances often seem to indicate that the ants have disposed of the larva but there is no definite proof of this. The ants enter through a break in the bark, enlarge the tunnel for their own living quarters, and greatly increase the original borer injury. A live or dead borer has never been found in the many galleries inspected where these ants were present.

On August 4th, at six localities, a total of 57 tunnels were opened. Larvae were normal in 42, clerid larvae were present in seven, and birds had destroyed the larvae in eight tunnels. The birds could not be seen actually ingesting the larvae but the results of their activity were obvious. Those species which I have commonly seen pecking at the bark of infested dogwoods are the black and white creeper, *Mniotilta varia* Linn., the downy woodpecker, *Dryobates pubescens medianus* Sw., and the white breasted nuthatch, *Sitta carolinensis carolinensis* Latham. Although these birds do destroy a considerable number of borers, they are rather inefficient in their work, for in a heavily infested section of a dogwood tree, larvae are often found near the bark surface and quite close to the spots where the birds have been active.

[1] Identified by J. C. Schread, Assistant Entomologist, Connecticut Agricultural Experiment Station.

Artificial Control

The degree of infestation of wounds is very closely correlated with the proximity and abundance of emerging adults, and in no instance have dogwoods been found severely infested when they were located 300 yards or more from an established infestation. Unfortunately, many nurseries maintain their own infestation by failing to destroy injured, gnarled and borer-riddled trees in their nursery rows. One nurseryman who has propagated dogwoods for many years points to the year when he eliminated all large dogwood trees from his nursery as the period when this part of the business became a financial success. Furthermore, specimens or blocks of dogwoods do not become infested, regardless of their age, unless breaks in the bark occur. When studying the efficiency of treatments, consideration should be given to the fact that under ordinary conditions seldom more than 30 per cent of the trees having bark injuries become infested during the year in which the injury occurs. But unless prompt and effective treatment is given before injury becomes extensive, the life of a planted dogwood is greatly reduced and infested nursery trees are generally a complete loss. Moreover, unless a bark injury heals smoothly and rapidly it is liable to attack in subsequent years.

In 1904 Herrick (15) suggested the application of grafting wax to the newly-set buds and to bark injuries of pecan as a protection against the pecan borer. Turner (32) suggests no particular control method but states that whitewash was ineffective in protecting pecan trees in Georgia. The work reported by Hamilton (13) indicates that a mixture of soluble pine tar and paradichlorobenzene diluted with water and sprayed on the trunk will kill hardwood borers, but it is injurious to dogwoods and other trees with thin bark. There is considerable doubt about the effectiveness of this mixture against the peach tree borer (25). Houser (18) tested several materials as a protection against borer injury and concluded that the best of these was paper wrapping. In recent investigations, Pierce and Nickels (27) reported that the most effective method of protecting scions of pecan from borer injury was to cover the wounds with a grafting wax that will not crack until after a good union is formed.

In extensive tests, Farrar (8) found that both of the long recommended repellent treatments, namely soap and naphthalene, and a whitewash formula containing sulfur failed to control shade tree borers. Furthermore, it is not practical to attempt control of the dogwood borer by trying to kill the larvae within their tunnels.

Tests of several other materials designed to prevent infestation by the dogwood borer have been carried out at five locations near New Haven. In most cases four to six uniform artificial injuries were made on the trunk of each tree with a sharp knife, one about three inches above the other, and a series of treatments were applied to each tree. For trials of DDT one control and one treated cut were used on each of 20 trees. In the report below, two borers were present in five injuries but in all others only one larva occurred. The records refer to the number of injuries infested, regardless of the number of larvae involved. Most of the injuries and treatments were made during May, although a few series were delayed until the first week of August.

Discussion of Control Treatments

Precautions against injury to the bark of dogwood trees are simple and effective in controlling the dogwood borer, but injuries do occur and methods of chemical control are required.

Grafting wax and other materials which are difficult to handle or prepare have been purposely omitted in these trials. The relatively low degree of infestation in the regular type of cut and the variability of infestation between plots make it difficult to compare small differences accurately but certain facts are immediately apparent.

TABLE 36. SUMMARY OF TREATMENTS[1] FOR *S. scitula* Harr. ON DOGWOOD

	Total	Number infested	Per cent infested
Regular cut, no treatment	52	15	28.8
Smooth cut, no treatment	57	3	5.3
Bruise, no treatment	42	16	38.0
Casein glue	15	7	46.7
Casein glue + lead arsenate	15	3	20.0
Lead arsenate wash	18	1	5.5
Shellac	36	2	5.5
Shellac and lead arsenate	40	0	0.0
Asphalt paint	26	0	0.0
DDT	20	0	0.0
Controls for DDT treatment	20	0	0.0

[1] Regular cut—An oval piece of bark, approximately 3" x 2" was removed, knife blade held at right angle to trunk.
Smooth cut—Made like an axe blaze, smooth and tapering at the edges.
Bruise—Bark of trunk was broken irregularly with a stone.
Casein glue—Regular cut painted with mixture of casein glue.
Casein glue and lead arsenate—As above, with 10 per cent by weight of lead arsenate added.
Lead arsenate wash—Lead arsenate at rate of one pound per gallon of water and 1/8 pound of aluminum hydroxide sticker, painted on trunk and over injuries.
Shellac—Clear shellac painted on regular cut.
Shellac and lead arsenate—As above, with 10 grams lead arsenate added per 100 cc. shellac.
Asphalt—Commercial brand of tree paint consisting of asphaltum mixed with linseed oil, applied with brush.
DDT—A commercial preparation at the dilution of 3 pounds pure DDT per 100 gallons of water, applied to the cuts with a small hand sprayer.

1. Casein glue with or without lead arsenate was ineffective. This is probably due to the fact that the casein glue coating, within a short time after application, cracks and breaks up into granular particles, thereby leaving unprotected openings through which the larvae may enter around a bark wound.

2. Bruises were apparently more commonly infested than the regular type of cut and smooth cuts were generally not attacked by the borers.

3. The lead arsenate wash appears to have either killed or deterred the larvae. A noticeable whitish-gray deposit remained on the treated tree trunks throughout the summer, making this treatment undesirable for general use.

4. Shellac, shellac and lead arsenate, and asphalt paint gave very good control. The two borers found in injuries treated with shellac had apparently entered through the crumbled film. All the evidence available indicates that the protection afforded by these materials is probably not in the nature of a chemical repellent but it is the smooth, protective film which seals the injured bark area and eliminates any place for concealment or protection of the larva while it is commencing a tunnel. This observation is substantiated by the reports of satisfactory control of *S. corrusca*, when grafting wax is coated over the injuries (27).

5. DDT trials offered no information because the corresponding controls were not attacked.

The dessication which occurs in tree wounds varies with the exposure; in protected, shaded areas little or no dieback of tissue occurred around the opened bark areas whether of the regular or smooth, axe-blaze type. Many injuries of the latter type, in the shaded forest, were completely healed over within six months but such injuries in an exposed location were subject to much more extensive dieback at the edges than were the regular type. The higher infestation in the regular, untreated cuts is probably due to the formation of an area in which the borers may obtain protection. The smoothing of the circumference of a cut when exposed to wind and sun intensifies the dieback, but the thin, dried inner bark at the edges of the injury appears to be unattractive to the young borers. In any case it is not considered advisable to repair an injury in this way.

The salutary effect on wound healing observed with some of the materials tested has been long considered due to growth-promoting properties of the wound dressing. However, the author has found in unreported investigations that there is no stimulus of the meristematic tissue by any of the substances commonly used in treating bark injuries of trees. Shellac is one of the substances commonly reported to possess such properties. The rapidity with which wound tissue forms is rather a measure of the degree by which the treatment prevents dehydration and consequent death or failure of the peripheral cells to function. Often, treatments reported to be the best are actually those which cause the least injury.

When any of the materials reported above are applied on fresh wounds of dogwood before the leaves are developed in the spring, an abundant flow of sap is likely to interfere with adhesion. If a film is formed at the time of treatment, sap pressure often causes the coating to bulge and leak and, when it finally dries, the covering may flake or peel off.

Properties of Materials Tested

Shellac

Shellac forms a hard film which is more elastic than generally supposed, but if applied in the spring it does crack and weather by mid-August so that a new application is required at that time. This is due to expanding growth more than to weathering. However, dogwoods should be examined at least twice during the season, and repainting is a small task. In these trials, a chemically inactive dye has been used to color the shellac so that the treated area is hardly distinguishable from the bark.

Asphalt-Linseed Oil

Asphalt paint at the proper consistency forms a thin, tough, elastic coating which resists weathering well. One coating will usually last throughout the summer. The black color is often considered undesirable and this paint is somewhat more unpleasant to handle than shellac. Although asphalt paint is effective in preventing attack by these larvae, it is ineffective against the large carpenter ant, *Camponotus herculeanus pennsylvanicus* DeGeer. These ants have been closely observed while engaged in clearing away carefully coated wound surfaces. The workers systematically cut off bits of asphalt and wood or bark and dropped them to the ground until a large area of fresh wood was exposed. The wound was then open for their continued activities and the only effect of the asphalt paint was to delay their destruction for a few minutes. In our observations, shellac coatings, similarly exposed, were avoided by the ants.

DDT

In recent preliminary tests by the author, the peach tree borer, *Sanninoidea exitiosa* Say, was effectively controlled in budded nursery peach trees when a spray containing 1 1/2 pounds of pure DDT per 100 gallons plus an effective deposit builder was applied to the stems in late June before adult emergence. The manner and general location in which the moths deposit their eggs is similar to that of *S. scitula*, and the habit of the larvae in crawling over an exposed bark surface before entering is common to both species. It was impossible to gain any information on the effect of this material on any stage of the dogwood borer from these tests because an infestation failed in the controls, but there appears to be no reason why DDT applied to the trunks of dogwood as it was to peaches should not be equally effective in controlling the dogwood borer.

Summary

Synanthedon scitula Harr. is a native pest of dogwood in the eastern half of the United States. Its biology, bionomics, and control are representative of a group of related species, the larvae of which attack trees at wounds or callous growths and injure the host by boring within the bark.

The adults emerge from late May through September and deposit eggs on the bark of the trunk or branches of dogwood trees. The peak of adult emergence occurs during the first two weeks of July. The newly hatched larvae become established only if they encounter a broken bark wound or cracked callous area of such a nature that immediate protection is available. There is one generation annually although larvae in all stages of development may be encountered throughout most of the year. The larvae hibernate within the bark and remain completely inactive only as long as air temperatures approach freezing. Pupation occurs in the larval gallery, close to the bark surface, and the cast pupal skin remains extruded through a round hole in the bark when the adult leaves.

In Connecticut the only host plant of importance is the flowering dogwood, *Cornus florida.*

The most abundant natural enemy encountered here is the larva of a species of Cleridae.

Control measures were directed toward preventing the entrance of the borers into injured bark surfaces rather than killing them after establishment. This has been successfully accomplished in replicated tests with shellac and with asphalt paint thoroughly covering the wounded surface. They were equally effective. When the advantages and disadvantages of both materials are compared, shellac will probably be preferred.

Dogwood trees should be carefully inspected at least twice during the year, in early spring and again in midsummer. Injured bark areas should be treated promptly.

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THE CORPORA ALLATA OF MOSQUITOES

DIETRICH BODENSTEIN
State Board of Mosquito Control

The corpora allata of insects, although known for a long time, have recently attracted anew the attention of the investigator. It was the discovery that these organs are glands of internal secretion which brought forth this sudden renewed interest. Hormones liberated by the corpora allata, it was found, play an important role in the processes of growth, metamorphosis and egg production; apparently they also regulate or control metabolic activity.

As far as the Diptera are concerned, knowledge regarding the corpora allata of the higher Diptera is not lacking, yet is by no means complete. We know much less about the corpora allata of lower Diptera. Only a few genera have been investigated (Chironomidae: Miall and Hammond, 8; Holmgren, 5; Frew, 3; Burtt, 1; Zee and Pai, 11. Tipulidae: Nabert, 9; Sellke, 10; Burtt, 1. Mycetophylidae: Madwar, 7), and the accounts are often rather fragmentary. Virtually nothing is known about the corpora allata of Culicidae. The first one to observe a structure in Culicidae which apparently represents the corpora allata was Dogiel (2) in his studies on the heart of the Corethra larva. He writes: "Ungefähr auf der Fläche wo das Hirn und Brustgliedchen des Körpers sich vereinigen, bemerkt man eine besondere scheinbar aus Zellen bestehende Masse, welche die Aorta an dieser Stelle rings herum umfasst; von dieser Masse gehen auf und abwärts zwei Fortsätze....." Imms (6) describes for *Anopheles maculipennis* larvae a supporting collar, "anneau de soutien". This is composed of cells which have no definite outline and are in some cases vacuolated. This structure is located just behind the brain and envelopes the aorta ventrally and laterally; it is single anteriorly, but bifurcates posteriorly into two projections.

It is the object of this study to describe in more detail than hitherto attempted the larval corpora allata in a number of culicid genera, and to show some of the changes the larval corpus allatum undergoes during metamorphosis.

Methods

For the total mounts of the corpora allata, these structures were dissected out from insects fixed in alcoholic Bouin. They were then stained with orcein and mounted in diaphane. Since these organs are very small and quite delicate, great care had to be taken at the dissection, which was done under the binocular microscope at a magnification of about 60 x. For sectioning, the material was also fixed in alcoholic Bouin. The 10 μ. thick sections were stained with Delafield's haemotoxylin and counterstained with orange G or eosin. Some sections were also stained with Bodian's silver impregnation technique.

The Corpora Allata of Mature Larvae

The larval corpora allata of the Culicidae are paired structures. They are small oval bodies which are always associated with cells of quite a different character. For this reason, it is preferable to speak of the corpus allatum complex rather than the corpus allatum. The term corpus allatum will therefore be used only when referring to this structure specifically. The corpus allatum complex is located dorsally in the anterior part of the thorax, somewhat anterior to the proventriculus, on the border where thorax and neck meet. (See Figure 11). Lying dorsally to the oesophagus, the complex is closely

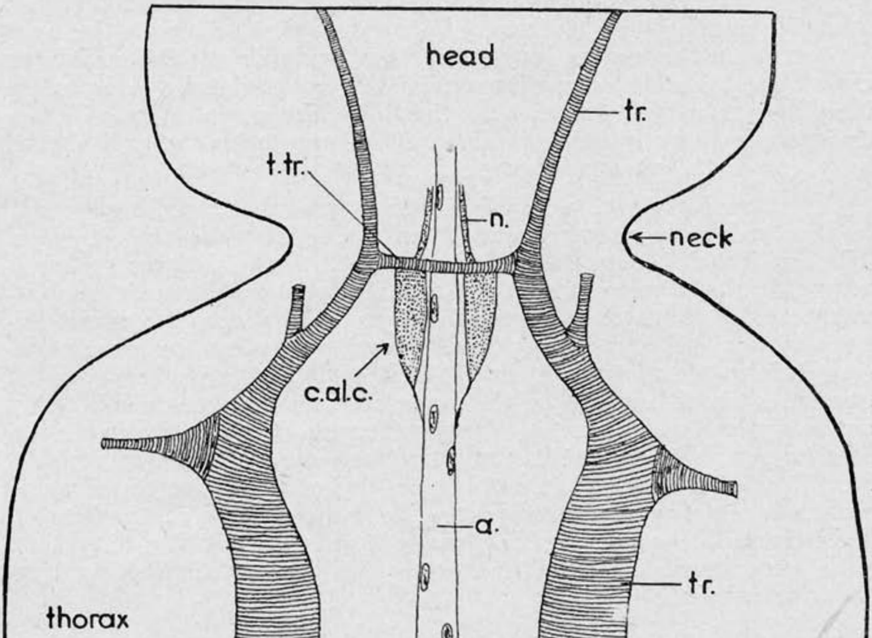


FIGURE 11. Diagram showing position of the corpus allatum complex in the larva.

connected with the aorta, which it envelopes partially. A good landmark for locating the corpus allatum complex is a well-de .ned transverse trachea which connects the two main lateral tracheae with each other a little below the neck. This trachea, the only transverse connection between the two main trunks in this region, passes dorsally over the aorta. The anterior border of the corpus allatum complex adheres closely to this tracheal stem, as may be seen in Figure 12: 2 to 9. The complex consists of two elongated cell structures, each of which projects backwards from the transverse tracheal trunk and lies laterally on the side of the aorta. These two separate structures are only united in the region of their attachment to the trachea, where they are connected by a loose chain of cells which partly envelope the aorta at this point. The main portion of these prolonged bodies consists of relatively large cells with large nuclei containing chromosomes in polytene condition. The cell borders are not defined. These cells form a thin sheath about 1-2 cell layers thick in the anterior portion. Towards the posterior end the structure gradually becomes thicker and, somewhat below the middle, encloses an oval body, the corpus allatum part of the complex.

The topography described can also be recognized in the photograph of the whole mounts (Figure 12 : 2 to 12 and Figure 13 : 13 to 15). The thin anterior cell layer may be seen very well because the light can penetrate this region very easily, thus bringing out the individual cells. The more distal portions gradually become darker, due to the inability of the light to penetrate the thickened organ. One will further note in some of the more favorable photographs the oval shaped body, the corpus allatum (Figure 12: 9).

Sections through the corpus allatum reveal that its cells are much smaller and more closely packed than the cells in the other regions. The relation of the corpus allatum complex to the nervous system is very difficult to trace without special methods and has not been attempted, for the nerves, especially those of the stomatogastric nervous system are exceedingly fine. However, as can be clearly observed from the pictures (Figure 12: 2 to 9), each of the elongated structures on either side of the aorta receives a nerve which enters anteriorly and which can be followed for a short distance into the tissues. Each nerve apparently supplies the corpus allatum on its side. Moreover, each of the paired structures tapers to a point distally and continues as a fine thread, which is closely attached to the aorta wall. This threadlike connection is usually torn away at the dissection. Whether or not it represents a nerve or only an attachment cord remains uncertain.

The Corpus Allatum Complex in Mature Larvae of Different Genera

The general anatomy and histology of the corpus allatum complex are very much alike in different genera of the Culicidae. The shape and size of the complex, however, vary within the different species, and even more, within the different genera.

Aedes (Figure 12: 5 to 8).

The general shape of the corpus allatum complex of the four Aedes species investigated is very similar. The organ is relatively short and broad, somewhat widened in the middle and comes to a rounded point distally.

Culex (Figure 12: 2 to 4).

In this genus, the complex is more or less triangular-shaped. The widest region of the organ is always the one attached to the trachea, from where it tapers gradually off, coming distally to a fine point.

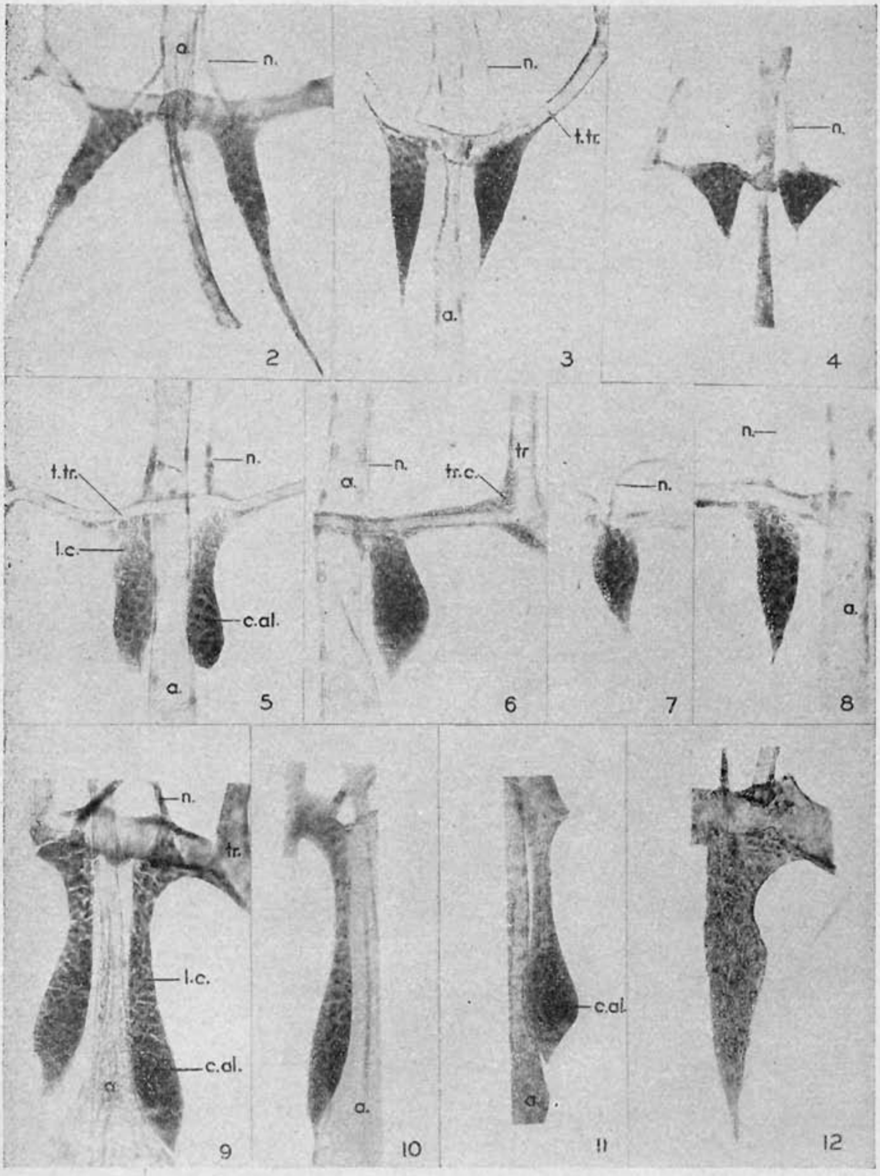
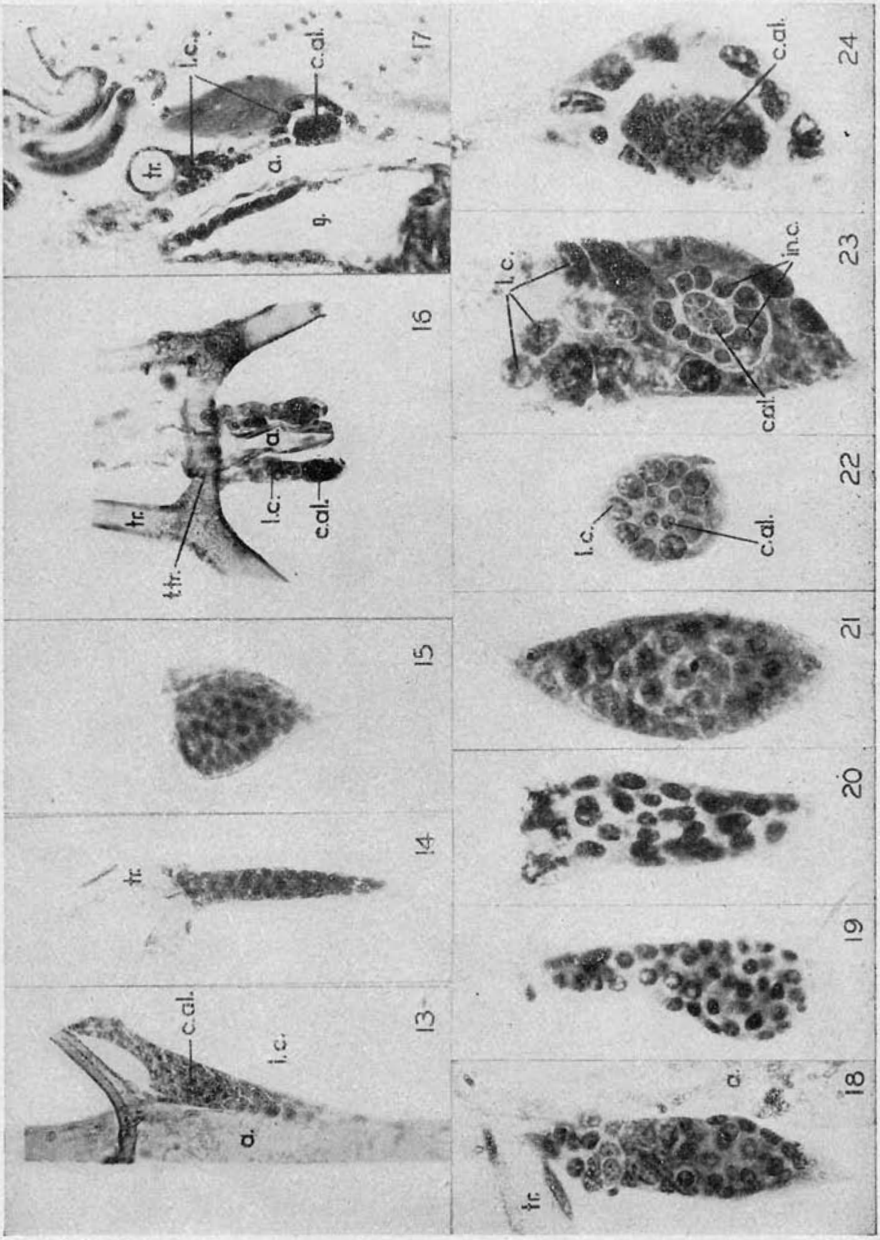


FIGURE 12. Whole mounts of the larval corpus allatum complex of different species. 2. *Culex territans.* 3. *Culex pipiens.* 4. *Culex apicalis.* 5. *Aedes aegypti.* 6. *Aedes cantator.* 7. *Aedes canadensis.* 8. *Aedes vexans.* 9. *Anopheles quadrimaculatus.* 10. *Anopheles punctipennis.* 11. *Anopheles walkeri.* 12. *Anopheles crucians.*

a., aorta; c. al., corpus allatum; l. c., large cells of the corpus allatum complex; n., nerve; tr., trachea; tr. c., tracheal cells; t. tr., transverse trachea.


13
a.
l.c.
c.al.
14
tr.
15
16
tr.
t.tr.
l.c.
c.al.
a.
17
tr.
l.c.
c.al.
a.
g.
18
tr.
a.
19
20
21
22
l.c.
c.al.
23
l.c.
in.c.
c.al.
24
c.al.

Anopheles (Figure 12: 9 to 12).

In the Anophelinae, the corpus allatum complex is an elongated structure shaped somewhat like a flask with a definite neck and a swelling below the middle, bearing at this point the corpus allatum. By their typical shape and considerable length, the corpora allata complexes of anopheline larvae are easily distinguished from those of other genera.

Other Genera (Figure 13:13 to 15).

In the other genera investigated, the corpus allatum complex varies in size and shape. *Psorophora ciliata* has a very short heart-shaped complex. In *Wyeomyia smithii* and *Uranotaenia sapphirina* the complex is an elongated structure which, as far as its shape is concerned, takes an intermediate position between Aedes and Anopheles.

The Corpus Allatum Complex of the Adult *Aedes aegypti*

The corpus allatum complex, like many other structures of the larval organism, undergoes metamorphosis; it is transformed during the pupal period into its final imaginal state. The location of the organ during this process does not change appreciably, for it is still found in the adult on the border between thorax and neck, where it remains closely connected to the aorta and a transverse tracheal trunk. However, drastic histological changes have taken place. The adult complex is much smaller than that of the larvae, as can be seen if one compares Figure 12:5 and Figure 13:16. Morphologically, the adult complex is represented by two small, roundish bodies, the corpora allata, each of which is located on the side of the aorta. These bodies are connected with the transverse tracheal trunk by a mass of rather loosely arranged cells. Sections reveal that this cell mass is made up of large cells with large nuclei and indistinct cell boundaries (Figure 13: 17 and 18). In the region of the corpus allatum, these large cells surround the organ with a single layer of cells (Figure 13: 18). The corpus allatum itself consists of a great number of small, closely packed cells with little cytoplasm (Figure 13: 18).

FIGURE 13. 13. Whole mount of the larval corpus allatum complex of *Wyeomyia smithii*. 14. The same, *Uranotaenia sapphirina*. 15. The same, *Psorophora ciliata*. 16. Whole mount of the corpus allatum complex of an adult *Aedes aegypti*. 17. Longitudinal section through the corpus allatum complex of an adult *Aedes aegypti*. 18-24. Sections through the corpus allatum complex of *Aedes aegypti* in different stages of development. (Scale of magnification the same for all stages in this series.) 18. Longitudinal section through the complex of a young last instar larva shortly after the last larval molt. 19-21. Longitudinal section of the complex of successively older larval stages. Note in 21 the light oval area in center of picture, indicating the appearance of the corpus allatum proper. 22. Cross section through the region of the corpus allatum complex of a larva about ready to pupate. Note small corpus allatum cells in center of picture. 23. Longitudinal section through the complex of a young pupa. Note the presence of three types of cells. 24. Longitudinal section through the complex of an adult mosquito.

a., aorta; c. al., corpus allatum; l. c., large cells of corpus allatum complex; g., gut; in. c., intermediate cells in pupal corpus allatum complex; tr., trachea; t. tr., transverse trachea.

The Metamorphosis of the Corpus Allatum Complex in *Aedes aegypti*

The corpus allatum of mature larvae, it may be recalled, is composed of two cell types. These are the large cells which comprise the major part of the complex and the small cells which are grouped together into an oval-shaped body, the future corpus allatum of the adult. This situation, however, is found only in the fully grown larva. In the younger larvae only one cell type can be recognized, which apparently belongs to the first type. It is only as the larvae approach pupation that the small cells appear. Whether or not these small cells are already present before they become conspicuous is difficult to say for the following reason. The large cells are of the type which grows by increase in volume rather than by cell multiplication. Since they are relatively small themselves in young last instar larvae, they might for this reason be indistinguishable from the small cells, should these be already present. The developmental events in the corpus allatum complex during the last larval instar are shown in Figure 13: 18 to 22. These figures show the corpus allatum complex of five successively older stages photographed at the same magni cation. Figure 13: 18 represents the complex of a young last instar larva shortly after the last larval molt, while Figure 13: 22 shows the same structure of a larva about ready to pupate. Figure 13: 19 to 21 shows intermediate stages of development. This developmental series brings out clearly the following three developmental events. 1. The cells we have termed "large cells" increase in size as the larvae become older. 2. Up to the stage shown in Figure 13: 20, only one type of cell can be distinguished in the complex. 3. At the stage shown in Figure 13: 21, the formation of the oval body with its special cell type begins. This is seen in Figure 13: 21 by the faint outline of a roundish cell structure inside the mass of large cells. Yet at this stage there is still no clear difference in cell size between the cells of this body and those surrounding it. A little later in development, however, as shown in Figure 13: 22, the two cell types are very distinct.

We have already mentioned that the adult corpus allatum complex also consists of two types of cells: of large cells, less numerous, and of small cells, more numerous, than found in the larvae. In the light of these facts, it is pertinent to ask whether or not the large and small cells found in the larval organ are identical with the two cell types found in the adult structure. As far as the small cells of the adult complex are concerned, their identity with the small larval cells seems to be certain, for one finds them in the right position and typical arrangement throughout the entire pupal period up to the adult stage. The large cells of the larval complex, however, are a different matter. The nuclei of these cells increase greatly in size at pupation and shortly thereafter. In the young pupa (Figure 13:23) these nuclei are tremendous, and many of them seem to undergo degenerative modifications. At the same time, a new cell type has appeared. Its nuclei are intermediate in size between that of the large and small cells (Figure 13: 23). Moreover, these new cells are grouped around the small corpus allatum cells in much the same way as the large cells which later surround the imaginal corpus allatum. From this, one is forced to conclude that the cell layer which envelopes the imaginal corpus allatum is not derived from the large larval cells but comes from a different kind of cell, those of the intermediate type, which make their appearance in the young pupa. These cells apparently grow in size as pupal development continues, until they reach their full size in the imago (Figure 13: 24). As far as the large cells which comprise the anterior part of the adult complex are concerned, their origin is problematical. Since, however, they closely resemble the cells surrounding the corpus allatum, we might regard them as identical.

On scrutinizing the situation with regard to the metamorphosis of the corpus allatum complex, we come to the following conclusion: the large cells of the larval complex are purely larval structures, which disintegrate during pupal life. The small cells present in the complex of the mature larvae represent the future corpus allatum of the imago. The large cells of the imaginal complex arise from cells which are detectable first in the young pupa.

Discussion

The identity of the structures composing the corpus allatum complex has to be discussed. Although this seems to be a simple matter, yet it is not. The corpus allatum complex is closely associated with the stomatogastric nervous system in insects. This is the difficulty, for our knowlege concerning this part of the nervous system is exceedingly hazy. Speaking of Diptera, and looking into the literature on this subject, one finds a fair number of investigations, but most accounts are old. The nerves of the stomatogastric nervous system are very delicate and difficult to trace without special efforts and methods. The older investigators made the effort, but they did not have the methods. The more recent investigators have had the methods, but their efforts are lacking. What apparently happens is that older ideas are taken for granted, without realizing how inaccurate some of the older descriptions of necessity must be. Moreover, with this sketchy knowledge as the background, the investigators relate and homologize structures and systems about which they know but little. The results of such efforts are, to say the least, not very enlightening. This lamentable situation exists for all Diptera, but it is especially noteworthy in lower Diptera. In the light of these facts, it seems to be rather futile at the present to compare and homologize the structures of the corpus allatum complex in Culicidae described here, with apparently similar structures found in other groups of Diptera. We shall thus restrict our discussion to a few remarks, for we know so little.

The only structure about which we can be reasonably certain is the paired corpora allata. In Culicidae, as one will recall, this organ is already present in the fully grown larva, and is represented in the imago by two roundish bodies located on either side of the aorta at the distal end of the complex. Corpora allata, or structures which must be regarded as such organs in lower dipterous larvae, have been described by Dogiel (2), Miall and Hammond (8), Holmgren (5), Imms (6), Frew (3), Sellke (10), Burtt (1), Zee and Pai (11). For the imaginal corpora allata of lower Diptera only two accounts are available. Nabert (9) has described the adult corpora allata in two tipulid species, yet in a recent paper by Zee and Pai (11), dealing with the metamorphosis of the corpus allatum complex in Chironomus, it is stated that the corpora allata atrophy during pupal life and are hence completely lacking in the adult. These findings are peculiar indeed, for it would be the first instance among the adult Diptera investigated so far, in which corpora allata are missing. We must hesitate to accept the evidence brought forth by Zee and Pai before the results of a reinvestigation are available.

What kind of organ is represented by the part of the larval complex made up of the large cells is difficult to say. Burtt (1) calls the paired organ, closely connected with the corpus allatum in tipulid larvae, the oesophageal ganglion. Sellke (10) names what is apparently the same structure the pharyngeal ganglion. In Chironomus larvae there is, according to Burtt (1), as far as one can make out, no mention of any structure in a position comparable to the situation in Culicidae. Yet Zee and Pai (11), again in Chironomus, find definitely a structure connected with the corpus allatum which they call "strand cells", which very much resembles the "large cell" structure in the culicid complex. These authors, moreover, find another paired organ located distally from the corpus allatum, which they regard as the corpus cardiacum. What has been and still is known in the literature as the pharyngeal or oesophageal ganglion is named corpus cardiacum by more recent investigators (see Hanström, 4). Whether or not the paired structures in Culicidae composed of the large cells are the corpora cardiaca is, however, not so certain, for we must remember that these organs seem to break down during pupal life. If they are the corpora cardiaca, what then are the large cells which make up the major part of the adult complex? We might assume them to be the corpora cardiaca too. The dilemma is obvious. One more point must be mentioned; it is by no means certain that all of the large larval cells degenerate, nor that the cells of intermediate size which appear during pupal life are new cells. It seems a plausible assumption that only some of the large cells atrophy and disappear, while the remainder undergo drastic changes, become intermediate in size and are gradually transformed into the large cell structure of the adult. From such a point of view and regarding the large larval cells as the corpus cardiacum part of the complex, the part of the imaginal complex containing the large cells is but the metamorphosed larval corpus cardiacum. With so much uncertain, it is well to remember that much of what has been said is suggestive rather than conclusive.

Summary

The larval corpus allatum complex in various genera of Culicidae is described.

The metamorphosis of the larval corpus allatum complex is presented in some more detail for *Aedes aegypti*.

Our present knowledge of the corpora allata in lower Diptera is discussed briefly.

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NOTES ON THE EFFECT OF ALUMINUM SULFATE AND KOLOFOG IN LIME SPRAYS APPLIED TO SOYBEANS AS REPELLENTS FOR THE JAPANESE BEETLE

J. Peter Johnson

Applications of hydrated lime, 20 pounds plus three pounds of aluminum sulfate in 100 gallons of water, were not entirely satisfactory when applied to the foliage of field-grown edible soybeans for control of the Japanese beetle during the season of 1943. Immediately following an application the beetles were less numerous, but the plants became reinfested within a few days. The amount of lime adhering to the foliage was not sufficient to maintain effective protection.

Laboratory tests with stickers and spreaders for lime were conducted on plants in the greenhouse, and Kolofog, in comparison with aluminum sulfate, appeared very promising. As the beetles, when caged, will feed on foliage sprayed with lime, field tests were necessary to determine the respective values of the materials.

In the spring of 1944, the edible soybean, variety Hokkaido, was planted in plots 17.5 feet square, each containing seven rows 30 inches apart. The plots were spaced 7.5 feet apart to provide a safety zone to offset wind drift of the spray materials. Each spray was replicated four times on randomized plots. The sprays, their concentrations, and the resulting beetle defoliation are given in Table 37.

The sprays were applied three times, the first on July 21 and 22, the second on August 1 and 2, and the third on August 16 and 18. The first application was made as soon as the beetles began to appear. The second and third applications were made as the beetles began to reinfest the plots sprayed with 20 pounds of lime, plus three pounds of aluminum sulfate to 100 gallons of water. This spray was used as a standard.

TABLE 37. SPRAY CONCENTRATIONS APPLIED TO EDIBLE SOYBEANS AND THEIR RESPECTIVE VALUES EXPRESSED IN AMOUNT OF DEFOLIATION

No.		Pounds		Pounds		Gallons	Per cent defoliation
1	Lime	20	Aluminum sulfate	3	Water	100	3.62
2	"	7 1/2	" "	2 1/2	"	100	6.12
3	"	15	" "	5	"	100	5.67
4	"	30	" "	10	"	100	2.65
5	"	10	Kolofog	1 1/2	"	100	6.75
6	"	10	"	3	"	100	5.33
7	"	10	"	6	"	100	5.25
8	"	None	"	6	"	100	5.25
9	Check (No treatment)						5.75

In recording the percentage of beetle defoliation, the leaf samples were taken from the five inside rows of each plot, omitting sampling for 18 inches at both ends of each row. Six samples were taken from each row, giving a total of 30 samples for each plot. As each test was replicated four times, the percentage of defoliation was based on 120 samples.

The No. 4 spray, containing 30 pounds of lime plus 10 pounds of aluminum sulfate to 100 gallons of water, gave results significantly better than the standard spray (No. 1) and the check (No. 9). None of the other sprays (excepting No. 1) gave any improvement over the check. An analysis was made of the crop yield for each treatment, based upon the air-dry weight of the beans and pods of 50 plants from each plot, and there were no significant differences among sprays.

The drought of the summer season of 1943 and of the spring and summer of 1944 resulted in retarding the population increase of the Japanese beetle and less defoliation occurred than was expected.

APHONUS CASTANEUS Melsh.

J. PETER JOHNSON

As previously reported (1), third instar larvae of the scarabaeid *Aphonus castaneus* Melsh. were collected in Connecticut by McCabe and White in 1941. In late September and October, 1942 (2), third instar larvae, probably of another brood, were taken from turf which had been badly damaged in the towns of Orange and Wallingford. These infestations were outbreaks of a local nature and larvae were found as numerous as 83 to one square foot of turf area. Other infestations were found in Bloomfield and Hartford.

Very little information was found in the literature on the life history and habits of this insect, so numerous field observations were made to obtain further data. When the first diggings were made in September and October, 1942, the larvae (the epipharynx and raster are shown in Figure 14) were found in the upper inch of soil. Later

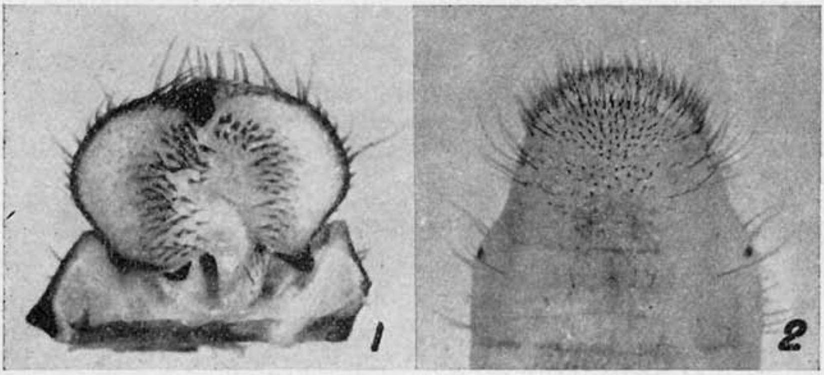

FIGURE 14. *Aphonus castaneus*. 1. Epipharynx, enlarged 24 times. 2. Raster, enlarged 7 times.

in October, just prior to the time the soil was frozen, the majority of the larvae were found in the upper four inches of soil. On April 1, 1943, a digging was made in Orange to a depth of 12 inches, the results of which are given in Table 38. As the turf was heavy and the soil contained many small stones, it was difficult to observe the location of the hibernating cells. Those which were observed were noted in the upper four inches of soil.

On April 3, 1943, a digging was made in Wallingford. The larvae were all less than six inches below the surface, with the majority in the upper two inches. Hibernating cells were more easily observed as the soil was comparatively free of stones. Skunks had been working at one of the infestations, unusually early in the season for them.

TABLE 38. DEPTHS AT WHICH LARVAE OF *A. castaneus* WERE FOUND ON APRIL 1, 1943

Depth in inches	Number of larvae	Per cent
1	2	50
2	31	
3	16	25
4	7	10.5
5	7	10.5
6	0	
7	2	4
8	1	
9	0	

TABLE 39. DEVELOPMENT OF PUPAE AND ADULTS IN THE FIELD

Date	Location	Larvae	Prepupae	Pupae	Adults
July 6, 1943	Orange	7	3	4	0
July 9, 1943	Orange	8	25	51	0
July 15, 1943	Orange	1	4	30	0
July 20, 1943	Orange	3	0	22	11
July 29, 1943	Orange	1	0	31	66

The first pupae were obtained in the field in the upper four inches of soil on July 6, 1943. Male and female pupae are pictured in Figure 15. The first adults were found in the soil in Wallingford on July 17, 1943 (3). The season was very dry and in the digging made on July 29, 12 of the pupae and 24 of the adults were found four to six inches below the surface, while the remainder were in the upper four inches. Field records of the development of the pupae and adults in Orange are given in Table 39.

No other diggings were made until August 17, 1943, and all of the insects found were in the adult stage.

A number of larvae and prepupae taken into the laboratory were reared to the adult stage at room temperature. The duration of the pupal period is shown in Table 40.

TABLE 40. DURATION OF PUPATION PERIOD OF *A. castaneus* AT ROOM TEMPERATURE

	Prepupa	Pupa	Adult	Pupal period
1	6-28-43[1]	7-18-43	8- 1-43	14 days
2	6-28-43[1]	7-10-43	7-24-43	15
3	7- 2-43	7-18-43	8- 1-43	14
4	7- 2-43	7- 7-43	7-22-43	16
5	7- 6-43	7-10-43	7-24-43	15
6	7- 6-43	7-15-43	7-29-43	15
7	7- 8-43	7-17-43	7-31-43	15
8	7-10-43	7-21-43	8- 5-43	16
9	7-12-43	7-15-43	7-28-43	14
10	7-12-43	7-15-43	7-27-43	13
11	7-12-43	7-18-43	8- 2-43	16

[1] Reared from larvae.

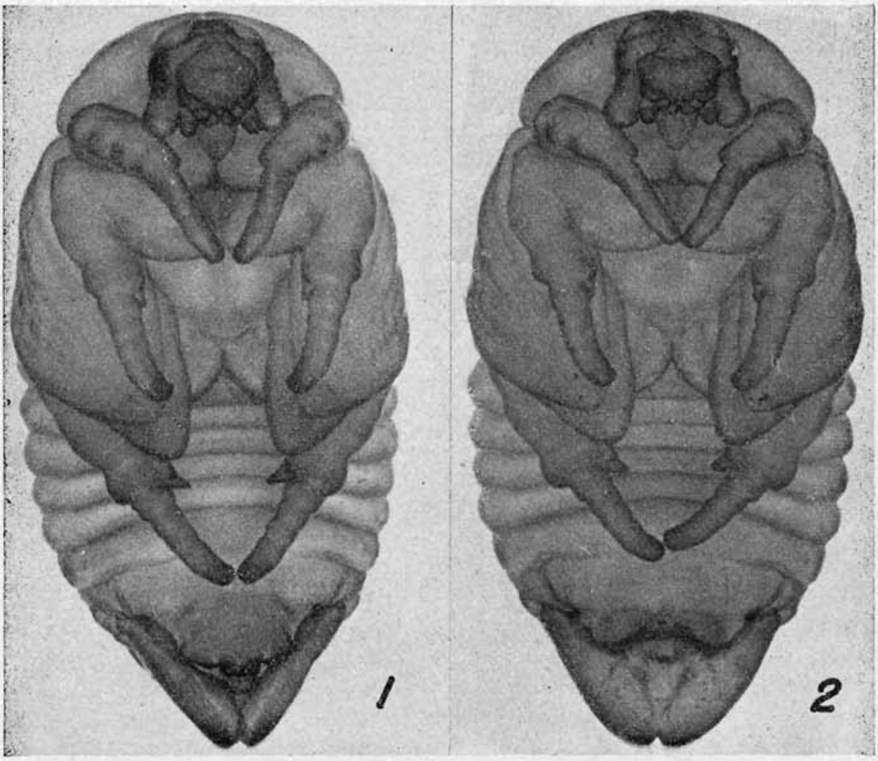

FIGURE 15. *Aphonus castaneus.* Pupae. 1. Male. 2. Female. Enlarged about 7 times.

Field observations were made at weekly intervals in 1943 for evidence of adult emergence. No adults were found above the soil and no emergence holes were seen. Adults were obtained from the soil during periodic diggings in the fall. Usually they were found in the pupal cell or nearby. As the season progressed, most of the adults were found at about four inches in depth. Those pupating at a shallower depth had moved downward as the soil became colder.

No eggs were found in the soil and a number of adults were taken to the laboratory for further examination. The ovarioles in the females were well developed but no mature eggs were present. Paired adults were kept in the laboratory at room temperature in small tins containing soil throughout the winter. No mating was observed at any time and no eggs were obtained.

During the early spring of 1944, a few adults were obtained from diggings in the field. On May 11, a total of 23 adults was found in the upper inch of turf over a considerable area being examined for Japanese beetle larvae. After numerous daily and a few evening observations in May and early June, two adults were taken on June 16 about 10 o'clock in the morning. One was observed emerging from the soil. It crawled over the turf for a short distance and took flight. The other was taken while trying to enter the soil. A few days later a few adults were observed in clumsy flight over the turf. The adults were never numerous. None was observed feeding nor taken on foliage. No eggs were obtained in the laboratory and none was found in the field.

Practically all the observations made from the fall of 1942 into the summer of 1944 were made at the infestations in Orange and Wallingford. At both places, in the fall of 1942, a mummifying muscardine fungus was observed to be rather prevalent. The vegetative or imperfect stage was identified as an *Isaria* sp., probably *militaris* (Figure 16). During the spring of 1943, this infection had increased

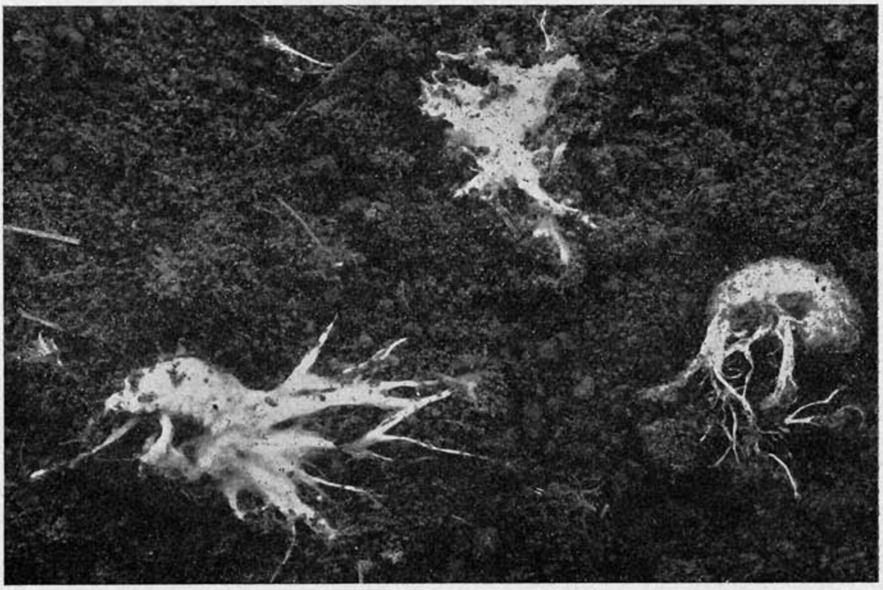

FIGURE 16. Vegetative stage of fungus, an *Isaria* sp., probably *militaris*, on larvae of *Aphonus castaneus*.

to such an extent that it was observed in every digging. Many of the insects which escaped its attack as larvae were infected with it in the pupal stage. Remains of dead pupae killed by this fungus were observed in diggings made as late as the spring of 1944.

A number of the larvae used in the summer of 1943, to determine the length of the pupation period, were found to be parasitized. The parasites pupated between September 10 and 20 but have not yet been identified as to species.

Summary

Large numbers of larvae of *Aphonus castaneus* were destroying turf in localized areas in four towns in the fall of 1942. The insects pupated in the months of July and August, 1943. The adults remained in the soil and hibernated during the winter. Only a small number of beetles were observed in flight in June, 1944, as the infestations were nearly decimated by a fungous disease and parasites.

The fungus, *Isaria* sp., was strongly established in the fall of 1942. It spread throughout the infestations in the spring and early summer of 1943, infecting larvae and pupae alike. As a result, there was a dearth of material in the summer of 1944 for rearing purposes. The small number of insects available died and it was not possible to obtain information on the egg or larval development.

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THE INCINERATOR BEETLE, Dermestes cadaverinus FABR.

J. Peter Johnson

The genus *Dermestes* includes a number of species primarily scavengers in habit. They feed upon decomposing bodies, hides, skins, hams, bacon, dry meat, furs, honeycomb, hair, etc. Two of the species of this genus are well known, the common larder beetle, *D. lardarius*, and the hide beetle, *D. vulpinus*. These two insects have been described and their histories are adequately presented in the literature. However, comparatively little information is available on *D. cadaverinus* and that usually in very brief notes. Data have been obtained from such sources and are assembled here, together with information obtained from local investigations.

Dermestes cadaverinus Fabr. is a cosmopolitan insect and has been reported feeding on dead cockroaches in Hawaii (3), silk cocoons, reel silk and leather near New York (1), copra in the South Seas (7), dried fish in Japan (5), dried mushrooms in imports (9), cacao, ginger and dried fruits in London warehouses (8), cheese and dried fish in the Dutch East Indies (4), and wool tops in N. S. Wales (2).

This insect was reported in Connecticut for the first time from South Norwalk on December 3, 1930. It was found infesting the material in the pit of an incinerator in the basement of a private home. After the incinerator was thoroughly cleaned, the insect nuisance subsided rapidly.

Since 1930, this insect has been recorded in this State 23 times, occurring in nine towns and in every month in the year. Five records are recorded for December, three each for May, October, and November, two each for January, February and June, and one each for March, April, July, August and September. It was established that one or more incinerators were present in each case, excepting two (in these two cases this fact was not determined) and, as a result, this insect has been termed the incinerator beetle, locally.

A flight of the beetles occurred in a large apartment building in New Haven, during the months of November and December, 1944, and continued into January, 1945. The peak flight occurred during the first two weeks of December with occasional heavy flights since then. There were several incinerators in this building and, as the flight persisted in two of the incinerator rooms, strong suspicion centered on them as the source of infestation. Upon inspection during the first week of December, 1944, the incinerators and chimneys, the latter also serving as disposal chutes, were found to be in good order. However, one dead larva was found in a small amount of soot on a small ledge above one disposal door in a chimney on the third floor.

While inspecting the basement, a large number of pupal cases were observed in floor sweepings, and others were seen in the debris adjacent to the junction of wooden partitions, masonry walls and floor. Others were found in the debris on the floor in a storage room containing fireplace wood. It was evident from the observation that the larvae had migrated from some source of infestation to pupate. Adults were observed in flight and crawling on the floors and walls.

Another inspection of the incinerators in the first week of January, 1945, revealed a very heavy infestation in the incinerator in the section where heavy flights were continuing. A large and continuous mouse infestation was also known to be present, and as the insects' food hosts are wide and varied, mouse cadavers in the partitions might serve as a continuing or intermediate source of infestation.

One apartment on the first floor, directly above one of the incinerator rooms, experienced intermittent flights of the insects from late November into January. In the evening, when the temperature was high, the beetles were very active. They would fly around the lights and annoy the family members when reading. They would fall into food, annoying dinner guests, or be found crawling around in general. A nightly catch often numbered 25 or more beetles. The adults were often observed coming out of crevices, from behind baseboards and moldings. Some larvae were also found emerging from behind the baseboards or on the floor in the kitchen. This indicated that the insects were present in the partitions. As a number of crevices and a few holes were observed in the basement ceiling directly beneath the apartment, it was possible for the insects to infest the apartment directly from the incinerator room.

Very little information has been found on the life history of this insect. It is not known whether the insect will successfully pass the winter out of doors in Connecticut. The only adults recorded in this State were collected in buildings and they have been found in every month of the year. This indicates that, under favorable conditions indoors, breeding may be continuous with overlapping generations occurring. Some of the adults collected in the apartment building were taken to the laboratory and lived for three and four weeks. A few eggs were deposited by the adults which had been collected and these hatched in five or six days.

Illingworth (3) found that the larval stage consisted of seven instars and varied from 28 to 41 days in length in Hawaii. He also found the pupation period was very constant and nine days in duration. He stated that the pupae invariably cast their last larval skin and were typical of coleopterous pupae. The writer, when inspecting the conditions in the apartment building, found one adult emerging from a larval skin located in dry debris. In the laboratory, however, in the presence of moisture, the pupae cast the larval skin.

Description

Adult

The adult, Figure 17: 1, is 7-9 mm. in length, black in color and clothed with a yellowish-grey pubescence. The second to fifth ventral abdominal segments, Figure 17: 2, have a row of black rounded spots, sometimes elongated posteriorly, on each side of the middle and another row of hook-shaped spots, curved posteriorly, on each lateral margin. The male has a fovea (6) with a tuft of yellowish bristles (8) present ventrally on each of the third and fourth abdominal segments.

Egg

The egg, Figure 17: 3, is about one mm. in length, white in color, banana-shaped and more bluntly rounded on one end. Its chorion is delicately ridged laterally on the concave surface and has longitudinal rows of very small indentations on the convex surface.

Larva

The larva, Figure 17: 4, is about 14 mm. in length. It is brownish to black in color dorsally with a longitudinal broken lighter stripe and is creamy-white or white ventrally. The head is dark, nearly black in color, the legs yellow, and the antennae yellow and white. Large mesothoracic spiracles are present with spiracles less than one-half in size present only on the first, second and third abdominal segments. Two slender thorn-like spines, slightly curved anteriorly, are present dorsally on the ninth abdominal segment. The larva is entirely, but not densely, clothed with long reddish-brown hair, usually characteristic of the dermestids.

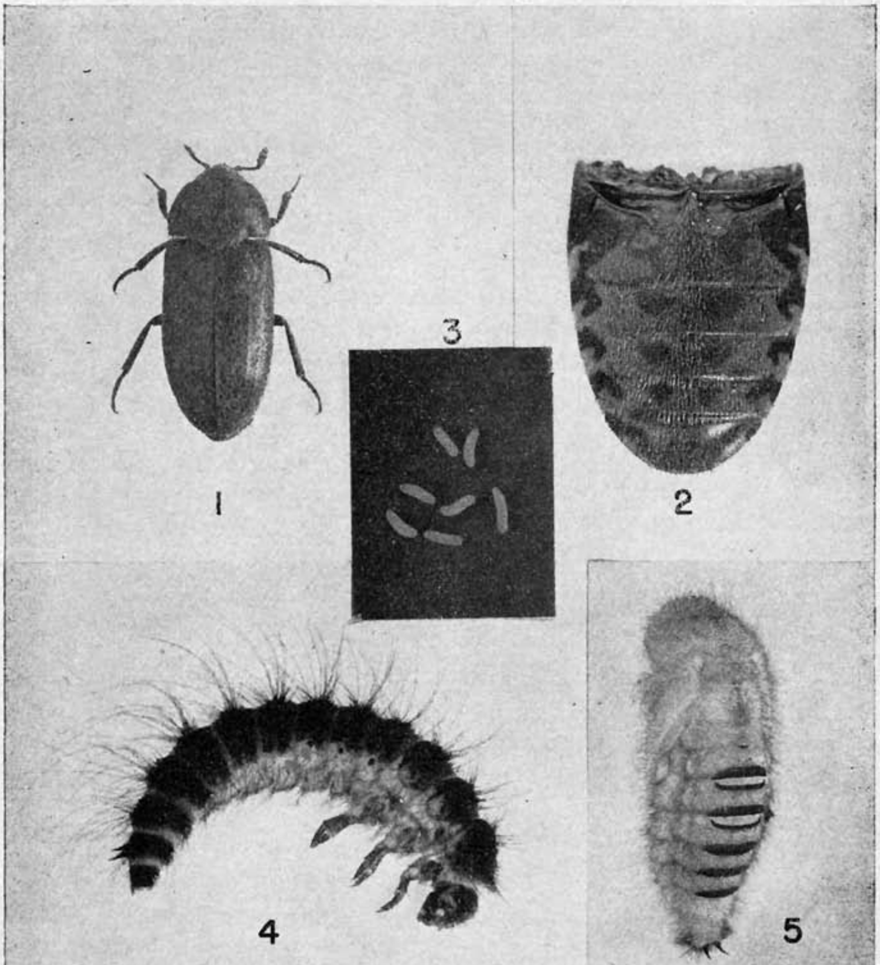

FIGURE 17. Incinerator beetle, *Dermestes cadaverinus* Fabr. 1. Adult, enlarged 5 1/2 times. 2. Abdomen of ♀ adult, ventral view showing hook-shaped spots on each lateral margin, greatly enlarged. 3. Eggs, enlarged about 6 times. 4. Larva, enlarged 5 1/2 times. 5. Pupa, enlarged 5 1/2 times.

Pupa

The pupa, Figure 17 : 5, is about 9-10 mm. in length, creamy-white or white in color and clothed with reddish-brown hair. A small dorsal plate is present anteriorly on the second abdominal segment while long narrow dorsal plates extend laterally along the sutural margins of the second, third, fourth, fifth, sixth and seventh abdominal segments. The posterior dorsal plate in each case overlaps the anterior plate of the adjacent segment. Two slender thorn-like spines, slightly curved anteriorly and similar to those on the larva, are present dorsally on the ninth abdominal segment.

Causes of Infestations in Incinerators and Their Control

Complete combustion, reducing all waste material to ash, is not obtained in the average small incinerator. This is due to insufficient dry, combustible material in the substance being burnt. As a result, partially burnt garbage remains in the ashes.

The odors from the burning waste materials or from the unburnt garbage probably attract the adult insects. Sometimes several weeks elapse before the incinerator is cleaned out, providing ample time for breeding. Careless cleaning, such as leaving debris in the corners of the ashpit, leaves material available for continuous breeding. Small ledges in the chimney or disposal chutes formed by protruding bricks, stones or disposal-door frames might protect the insects sufficiently to form breeding areas.

General infestations in incinerators may be avoided by thorough removal of all ashes and unburnt material at least every two weeks. Weekly removal would reduce the possibility of an infestation to a minimum.

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EGG PARASITISM OF THE FALL CANKERWORM, Alsophila pometaria (HARRIS)

JOHN C. SCHREAD

For several years the fall cankerworm, *Alsophila pometaria* (Harris), has been increasing in abundance in various parts of Connecticut, at times reaching outbreak proportions in certain localities. During the spring of 1944, extensive damage was done in towns in Fairfield and New Haven counties as well as in other parts of the State. Over a span of many years, sporadic flare-ups of both the fall and spring cankerworms have generally resulted in defoliation of ornamental, forest and orchard trees.

When trees are sprayed with arsenate of lead as foliage is developing in the spring, control of the worms is assured. However, in the absence of a standard spray program augmenting other forms of control, such as tree banding, cankerworms may occasionally multiply unchecked until forces of nature begin to operate against them.

The suppression of outbreaks of either or both of the geometrids under discussion has not been due entirely to artificial control measures. In addition to that which is being done by organizations directly concerned with the problem of holding the insects at low population levels, nature has, through the agencies of insect parasites and predators in conjunction with disease, often achieved virtual control of the pests.

Owing to the presence of many thousands of *Alsophila* egg masses on the trunks and branches of shade trees in sections of New Haven in early December, 1943, it was considered advisable to make systematic collections of the material, in quantities suitable to ascertain to what extent the egg masses had been attacked by parasites and the species involved.

The scope of the work was expanded to include a number of localities in New Haven and in Fairfield counties. Recognizing the possibility that cankerworm egg masses may not be attacked by parasites in late fall and early winter of the year in which they are deposited, and that a certain amount of parasitism might occur the following spring before the eggs hatch, it was deemed expedient to make collections, not only at the time moths were laying eggs in December, but also during the winter and early spring of the following year.

The accompanying table gives in detail a record of cankerworm egg mass collections in eight localities, four in New Haven County and four in Fairfield County. Three of the localities, one in New Haven County and two in Fairfield County, were revisited a second time between the last of February and the twentieth of April. A total of 51,001 eggs were collected, averaging 71.2 per cent hatch when held under controlled conditions in the laboratory. Eggs that did not hatch were either injured in removing them from the trees or they died from undetermined causes other than parasitism.

TABLE 41. FALL CANKERWORM EGG PARASITISM. LATE FALL, 1943, WINTER AND EARLY SPRING, 1944

Location	Date	Number eggs collected	Per cent egg hatch	Number parasites reared	Species	Per cent parasitism
New Haven	Dec. 9	910	69	..	..	..
East Haven	Dec. 12	2,017	75	..	..	..
Bridgeport	Dec. 12	7,154	75	10	*Telenomus alsophilae* Vier.	.18
Stamford (Courtland Park)	Dec. 10	7,490	61	..	..	..
Fairfield	Dec. 20	7,350	74	20	*Telenomus alsophilae* Vier.	.36
New Haven (Conn. Agr. Expt. Station)	Dec. 28	14,264	80.9	..	..	..
New Haven	Jan. 11	3,624	72	5	*Trichogramma pretiosa* Riley	.19
North Stamford	Feb. 21	606	61	..	..	..
Stamford (Courtland Park)	Feb. 21	2,742	73	..	..	..
Bridgeport (Beardsley Park)	Apr. 15	1,280	..	..	..	..
New Haven (Conn. Agr. Expt. Station)	Apr. 20	3.564	..	..	..	..

Thirty-five parasites were reared from the 36,313 eggs that hatched. Thirty of these represented the species *Telenomus alsophilae* Vier., superfamily Proctotrypoidea, family Scelionidae; the remaining five belonged to the species *Trichogramma pretiosa* Riley, superfamily Chalcidoidea, family Trichogrammidae. The sex ratio of *Telenomus* was two females to one male; that of *Trichogramma*, four females to one male.

The parasitism which existed in the *Alsophila* egg masses was very low. It is interesting to note, however, that the parasitism occurred sometime during early December, the assumption being there were no eggs available to the parasites until after the last of November. In view of the cold weather prevailing at that time of the year, it is somewhat surprising parasites were present and sufficiently active to find and parasitize the host. It is known, however, that *Trichogramma* will develop from egg to adult and emerge in 30 days at 47°-49° F. This may also apply to *Telenomus*. If such is the case, both species are capable of activity rather late in the fall especially on clear days when the sun, shining on the bark of a tree, would raise the temperature of the bark somewhat above that of the surrounding air. Consequently, owing to the possibility of a large part of cankerworm egg deposition being made on the south or warm side of a tree when exposed to direct sunlight, the parasites under favorable conditions would find the environment in the vicinity of the egg masses rather comfortable and thereby conducive to reproductive activities.

MISCELLANEOUS INSECT NOTES

Notes on a Spray for Controlling Japanese Beetles on Grapevines. A report on sprays for the control of the Japanese beetle was made by Johnson and Garman in the Forty-Third Report of the State Entomologist, pp. 280-281. A spray containing lead arsenate, 6 pounds; white oil (80 viscosity), 1/2 gallon; bentonite, 1 pound; Ultrawet spreader, 1/4 pound, and water, 100 gallons, afforded the most complete protection.

On July 13, 1944, one application of this spray was applied to an entire vineyard (small but heavily infested) on Waite Street, Hamden, with the exception of about 40 feet of one row which was left as an unsprayed check. At the time of application, the beetles were beginning to emerge in numbers and infest the foliage.

The vineyard was visited at least once a week until early September and less often thereafter to observe the results. Excellent control was obtained and only an occasional leaf, of the foliage existing at the time of spraying, was fed upon lightly. The unsprayed check was severely defoliated and the grapes upon these particular vines were unsatisfactory for harvesting. The new growth on the sprayed vines was defoliated to some extent but not seriously. The vines were not pruned to remove excessive foliage before or after the spraying, and sufficient foliage was therefore protected by the spray to produce a good yield. [J. PETER JOHNSON]

Notes on Seasonal Abundance of Scarabaeid Grubs and Their Injury to Turf. The status of the grubs of the Japanese beetle during the season of 1944 is given in another section of this bulletin.

Grubs of the scarabaeid *Aphonus castaneus* Melsh., which were abundant in the seasons of 1942 and 1943, were not troublesome during the past season and no evidence of turf damage by them was found.

Turf damage caused by white grubs, *Phyllophaga* sp., was reported from Madison. Approximately four acres on a golf course in Naugatuck were generally infested and the second year grubs had killed large areas of the turf. About two acres of turf on an athletic field in Avon were infested. Skunks had worked over this infestation and numerous small areas were torn up in their search for the grubs. Reports were also received in August of infestations in lawns in Simsbury and South Woodstock.

Only one report of lawn damage caused by the oriental beetle, *Anomala orientalis* Newm., was received in 1944. None was received on the Asiatic garden beetle, *Autoserica castanea* A., or the annual white grub, *Cyclocephala borealis* A.

The effect of the droughts in the summers of 1943 and 1944 was twofold. First, there was a definite decrease in the population of the Japanese beetle grubs and, possibly, those of the Asiatic garden beetle, annual white grub and oriental beetle, as these insects also have a one-year life cycle. The species of *Phyllophaga* reported as injuring turf have a life cycle of three years, with the second year grubs present in 1944, and these were not greatly affected by the dry conditions. Secondly, the grubs, under dry conditions, would feed deeper in the soil and in some cases cause less injury. [J. PETER JOHNSON]

A New Parasite of Japanese Beetle Grubs. During the course of laboratory work on the "milky" disease of Japanese beetle grubs, a few tachinid larvae were found, parasitic within the beetle grubs. In two cases they were accidentally discovered while dissecting grubs for another purpose. In other cases the mature larva was found within the skin of a dead grub or emerging from it. Also, a very few pupae were found. The total number of parasites was not recorded, and the grubs, being used for "milky" disease experiments, were not handled in such a way as to recover all the parasites. Consequently, the extent of parasitism is not known. The parasitized grubs had been kept in cold storage following their collection at the New Haven Country Club. One parasite may have come from material collected in Wallingford, and two parasite pupae were collected by Mr.

Schread—one in Hamden and one in Darien. It would seem that the parasite was well established, if not numerous.

The identity of the parasite has not yet been confirmed. Attempts to rear the adult from pupae yielded only one. This specimen was sent to Dr. C. H. Curran of the American Museum of Natural History, who reported that it was probably a species of Macrometopa or closely related genus. The specimen was forwarded to Washington, for further identification.

The habits of the parasite are presumed to be similar to those of *Prosena sibirita* and *Dexia ventralis.* The respiratory connection of the parasite is with the trachea of the host as with *Prosena*, and not with the integument as with *Dexia.* The characteristic tracheal funnel is present. [Raimon L. Beard]

Notes on the Sod Webworm. A heavy infestation of sod webworms, *Crambus* sp., damaged turf areas along the Wilbur Cross Parkway in the towns of Milford and Orange during the last part of May and early June. Several species were present, with *Crambus laqueattelus* Clemens and *C. trisectus* Walker very numerous. *C. mutabilis* was also found. The adults were abundant during the summer season and were taken also in New Haven and Shelton.

Ten pounds of lead arsenate mixed with 100 gallons of water and applied at the rate of 25 gallons to 1,000 square feet of area is an effective control for the larvae. As Japanese beetle larvae also were infesting the turf along the parkway, lead arsenate was applied at the rate of 10 pounds to 1,000 square feet of turf area. This heavy application is the standard application for Japanese beetle grub control and in this case served a dual purpose. [J. Peter Johnson]

Armyworms. On September 25, the Farm Bureau of Middlesex County reported large numbers of larvae feeding on millet in East Hampton. Upon investigation they proved to be armyworms, *Leucania unipunctata* Haworth. When the field was visited on the following day, the millet had been cut and most of the larvae were in depressions on the ground under the cut millet. The worms had eaten about one third of the leaves on about one half of the one-acre field. Many of the worms had tachinid eggs on them and were being eaten by crows and grackles. The field was surrounded on three sides by pasture land where they could do little damage, but there was a chance of injury to a new seeding of clover which adjoined one side of the millet field. [M. P. Zappe]

The Sawfly, *Acantholyda erythrocephala* L. One adult sawfly of this species was collected in South Meriden, Connecticut, in 1942, the first record of the insect in this State. Although it doubtless had been present here for several years previous, injury to host trees was not observed until 1943. Since then the insect has been found in several other localities in southern Connecticut, notably in the cities of New Haven and Waterbury, and along the Merritt Parkway in Fair..eld County.

The infestation along the parkway was fairly heavy (particularly in Westport) since many of the trees were noticeably defoliated.

The only observed host species was white pine (*Pinus strobus* L.), consisting of trees up to 18 feet in height. The other records are also for ornamental trees and include white pine, red pine and table mountain pine (*P. pungens* Lamb.). [G. H. PLUMB]

Black Carpet Beetle. A shirt manufacturer complained about insects dropping down on girls who were operating sewing machines in his factory. We investigated this complaint and found that the previous tenant had made woolen garments, and large amounts of lint had been left in the building, particularly between the floors. This material was breeding numbers of larvae of the black carpet beetle which were dropping from the ceiling, annoying the girls. A few adult beetles were also found to be present. [M. P. ZAPPE]

Clover Mites. A federal housing project in Windsor Locks was found infested with clover mites in early May. The buildings were new and the lawns were in poor condition. Mites were entering the buildings around the windows and doors on the south side of the houses. Large numbers were present on windows both indoors and outside. The new insecticide, DDT, was tried in both liquid and dust form but apparently had little if any effect on the mites. The nuisance was finally abated by treating the ground and south side of the buildings with sulfur dust. [M. P. ZAPPE]

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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.

INDEX