A PRELIMINARY STUDY OF THE EFFECT OF DDT ON APHIS MAIDIS FITCH AND ITS INSECT ENEMIES WITH PARTICULAR REFERENCE TO APHIDIUS (LYSIPHLEBUS) TESTACEIPES (CRESS.)[1]

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The discovery of the "wonder killing powers" of DDT spurred economic entomology. A great deal of experimental work was undertaken to determine the toxicity of DDT to various economic pests. Often DDT surpassed any other method of control.

Irregularities occurred, however. In some specific instances observations have been made of huge populations of insects or mites being built up after DDT treatment. The cause of this irregularity was not known and the question arose: Is DDT more toxic to the natural enemies playing an important role in the checking of pests than to the pest itself? If this were true, the biological cycle might be radically upset resulting in a large increase in the pest population.

Unfortunately, the trend in insecticide study has been to ignore the beneficial insect. Little attention has been given to the effect of various insecticides on parasites, predators, or pollinators. With these things in mind, a comparative study which would involve both the host population and its natural enemies was undertaken. This paper reports the observations of such a study.

During the summer of 1945, heavy populations of the corn leaf aphid, *Aphis maidis* Fitch[2] were present on field corn near Columbus, Ohio. There was heavy parasitism of this aphid by a braconid parasite, *Aphidius* (*Lysiphlebus*) *testaceipes* (Cress.).[3] This aphid and parasite were used as test insects. Many other biological enemies of this aphid including coccinellids, chrysopids and syrphids were present, and when possible, their activities were noted.

Biology of Host and Parasite

The biology of the principal insects involved in experimental work is reviewed briefly.

Aphis maidis Fitch

To quote from *Destructive and Useful Insects* by Metcalf and Flint:

> "Own knowledge of the life history of this insect is incomplete. In the North Central States, it appears in the corn fields about midsummer. In the South the insect multiplies rapidly and does its greatest damage in the winter months. Of the females, only the winged and wingless ovoviviparous

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[2]Determined by P. W. Mason.

[3]Determined by C. F. W. Muesebeck.

forms are known. Males have been noted only very rarely and the egg-laying true females have never been found. No observations have been made on the winter stages in the northern states, and it is not known whether this species passes the winter in the egg stage in this section or whether it migrates up from the South during the spring and early summer. . . . The number of ovoviviparous generations produced in a year varies from about 9 in Central Illinois to as many as 50 in southern Texas. The insects feed until they are killed by a heavy frost, or the drying up of their food plants."

This insect prefers sorghums, but may be found on corn, barley, sugar cane, millet, broomcorn, Sudan grass and many other plants of the grass family.

The corn leaf aphid is destructive to corn by feeding on the tassel and silk and coating them with honey dew which seriously interferes with pollinization of corn. Also, great numbers of corn earworm moths may be attracted to the honey dew on the ears. When corn is infested by this insect, numerous greenish or greenish-blue aphids appear in the curl of the leaves or upper stalk; sometimes they may entirely cover the leaves.

Aphidius (*Lysiphlebus*) *testaceipes* (Cress.)

A. testaceipes (Cress.) was chosen for a specific study because of its very large numbers in the field. In many instances 100% parasitism of the aphid host occurred.

It has been found that the life cycle of this insect takes from 7 to 15 days in passing from egg to adult during August and September (Webster and Phillips, 1912). The females begin ovipositing under favorable conditions within a few hours after emerging from the host. The oviposition period lasts from three days to a week depending upon temperature. The females may live and oviposit for five or six days in warm weather. This parasite is not active at a temperature much below 56° F. Aphids begin to reproduce at a temperature at or slightly below 40° F., allowing considerable damage to be done during temperatures at which development of this parasite is retarded.

Field Testing

Methods—

A survey of corn fields showed the heaviest infestations of the corn leaf aphid to occur on the outside edges of each field. This suggests that the aphids came to the corn from some border weeds and gradually worked their way toward the middle of the corn planting.

Infested corn plants within the first few rows of the field were classified as having heavy, medium, or light infestations. Plants having heavy infestations were selected for treatment. Each treatment was replicated four times, and each plot consisted of one corn plant. The insecticides were applied with hand knapsack sprayers and dusters.

Cages—

Cages were constructed and placed over the tassels or upper parts of the stalks after treatment. These cages were made of a fine mesh cheesecloth and constructed with sleeves at either end which were tied to the stalk. Cages used in field experiment 1 were constructed with a celluloid frame (see Cage 1, figure 1). In field experiment 2 the cage was simplified (Cage 2, figure 1). The celluloid frame was dispensed with and the cage was kept from collapsing by the pressure which the corn tassels exerted against the walls from within. Easier to construct, it proved to be as satisfactory as cage 1.

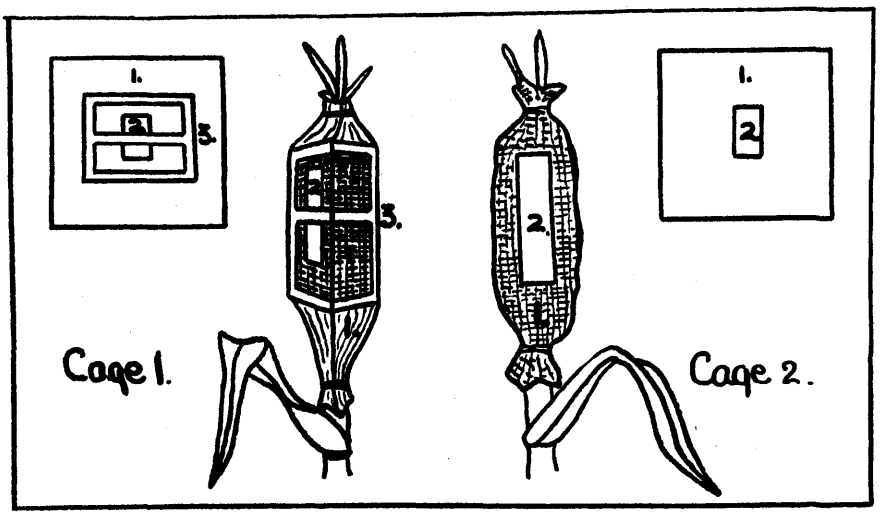


FIGURE 1. Construction of Cages, Field Experiments.
1=cheesecloth covering, 2=celluloid window, 3=celluloid frame.

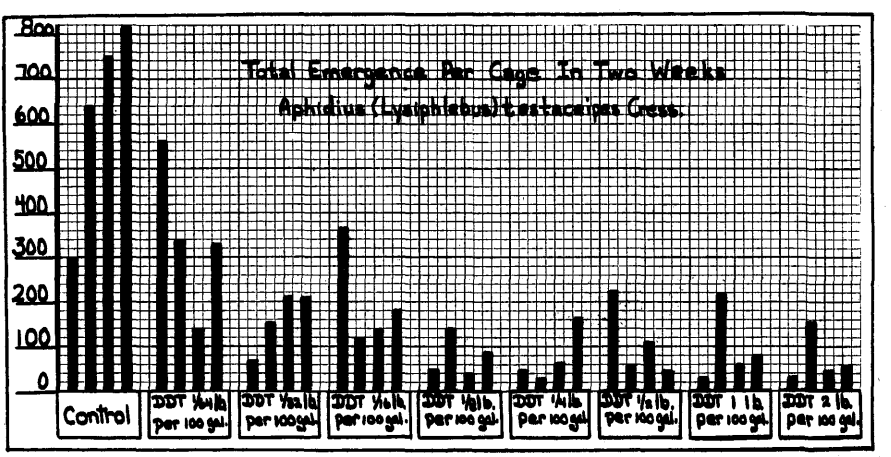


FIGURE 2. Parasite Emergence, Laboratory Experiment.
Histograms show total emergence for each cage (four cages per treatment).

INSECTICIDES—

For dosages used in each test, see Plates I, II, and III. Field experiment 1 was a test involving several formulae using different solvents. Field experiment 2 was based on concentrations of DDT from one formula using the same solvent.

The DDT (2, 2-bis (p.-chlorophenyl) —1, 1, 1-trichloroethane) used in suspension was received from the Geigy Company (G.N.B.A. mix 517) and consisted of 99.2% DDT. Stock formulae were prepared as follows and diluted to the desired concentrations:

DDT Benzol Formula:

DDT, 4 lb.; benzol, 1 gal.; B1956, ¼ pint.

DDT IDM #160 Formula:

This formula was received from R. D. Chisholm (Insecticide Division, Bureau of Entomology and Plant Quarantine), Moorestown, New Jersey. DDT, 1 lb.; Triton x 100, 1 lb.; Span 20 (sorbitan monolaurate—a product of Atlas Powder Company), 1 lb.; mix in enough acetone to make one gallon of stock solution.

DDT Kerosene Formula:

DDT, 5 parts; kerosene (commercial), 91 parts; B1956, 4 parts. On the dust plots, a Geigy 10% dust diluted in pyrophyllite was used.

For comparison with DDT, two other recommended aphicides were used.

(1) Nicotine-rotenone dust consisting of 1% rotenone to equal parts of sulfur and tobacco dust. (Bureau of Entomology and Plant Quarantine recommendation.)

(2) Black Leaf 40 at the rate of ¾ pound Black Leaf 40 per 100 gallons of spray.

DATA—

Aphid populations in the field were often so huge that they nearly overlapped covering every available space on a leaf, stalk or tassel. Due to the difficulty and lack of time and help to make actual counts, the investigator set up a scale, classifying the relative size of the population as very heavy, heavy, medium heavy, etc. Only living aphids were considered.

The parasite population was classified in the same manner with these exceptions. Both the number of adult parasites which had emerged and the number of parasitized aphids were considered.

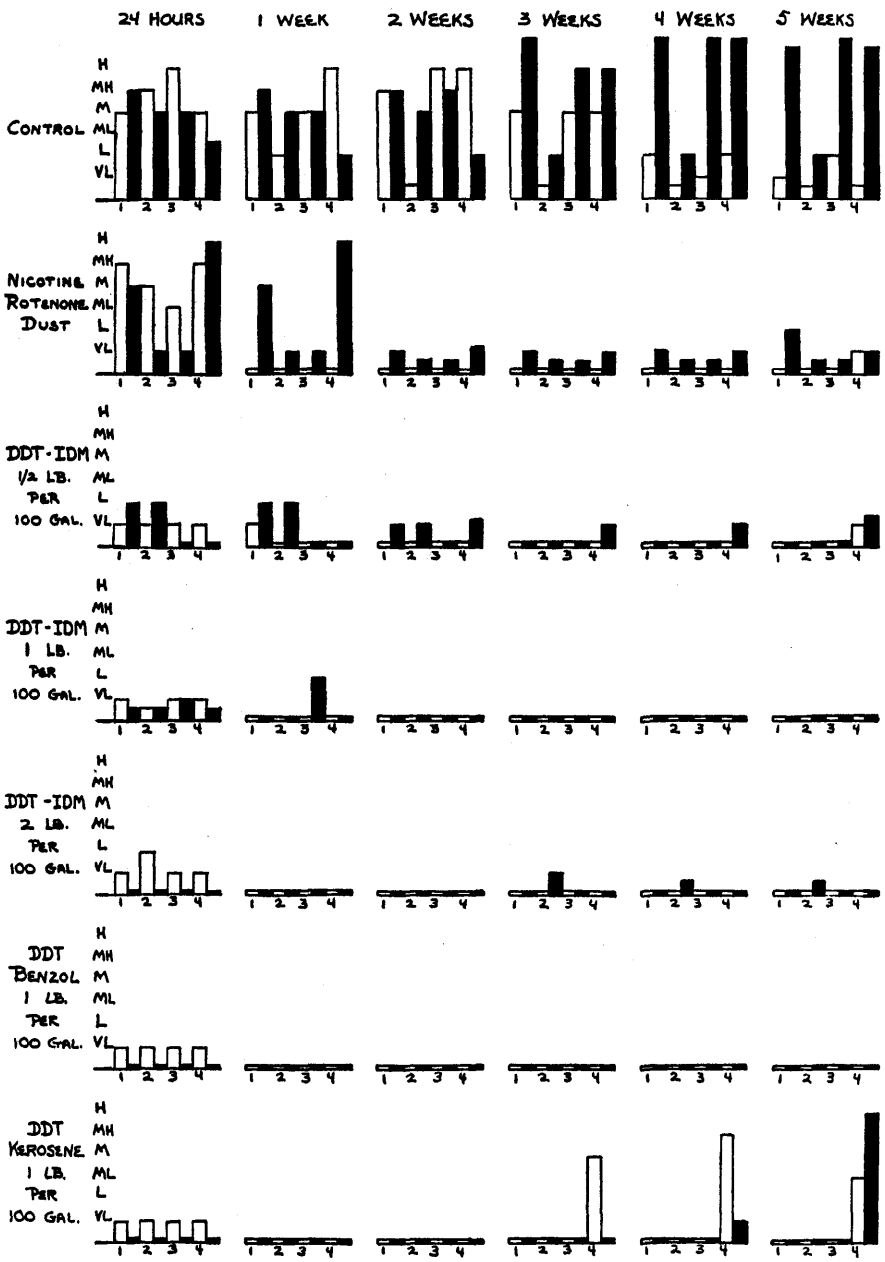
FIELD EXPERIMENT 1—

Data were recorded twenty-four hours after treatment and then once a week for a period of five weeks (see Plate I). The data plotted in the histograms on Plate I show that twenty-four hours after treatment both aphid and parasite populations of all DDT treated plots were greatly reduced. The control of the aphids at first appears better with DDT than with nicotine-rotenone dust. But, one week after treatment, the data show a disappearance of the aphid population on the nicotine-rotenone dust plots with the parasite population remaining higher than on any of the plots treated with DDT.

An irregularity appeared on #4 plot of the DDT-kerosene emulsion treatment. After the third week, the aphid population rose very rapidly. Those parasites which had not been exterminated by DDT staged a come-back that was noticeable the fourth week and was lowering the aphid population in the fifth week.

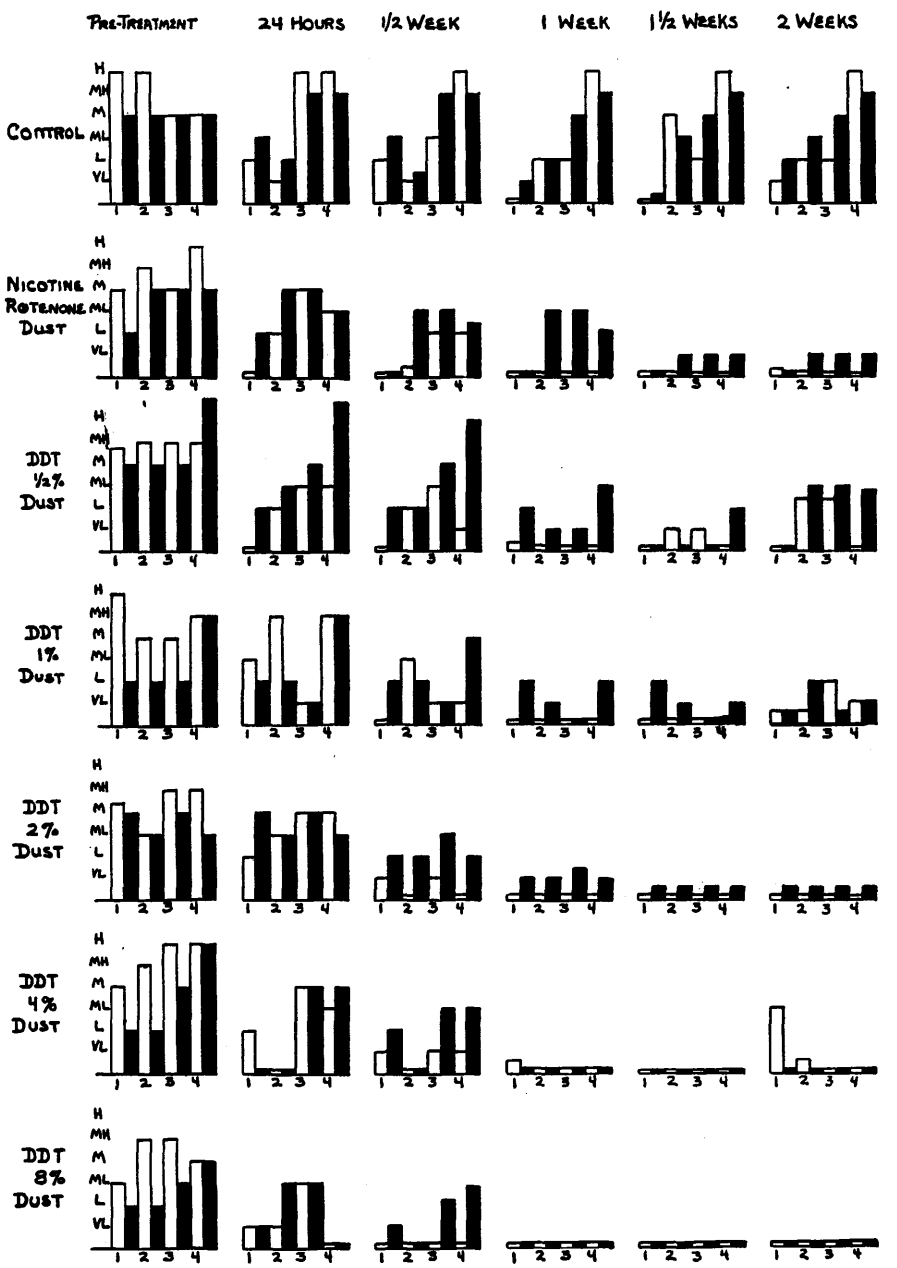
FIELD EXPERIMENT 2—

Data were recorded and analyzed in the same manner as in experiment #1 with slight variations. Observations were made twenty-four hours after treatment



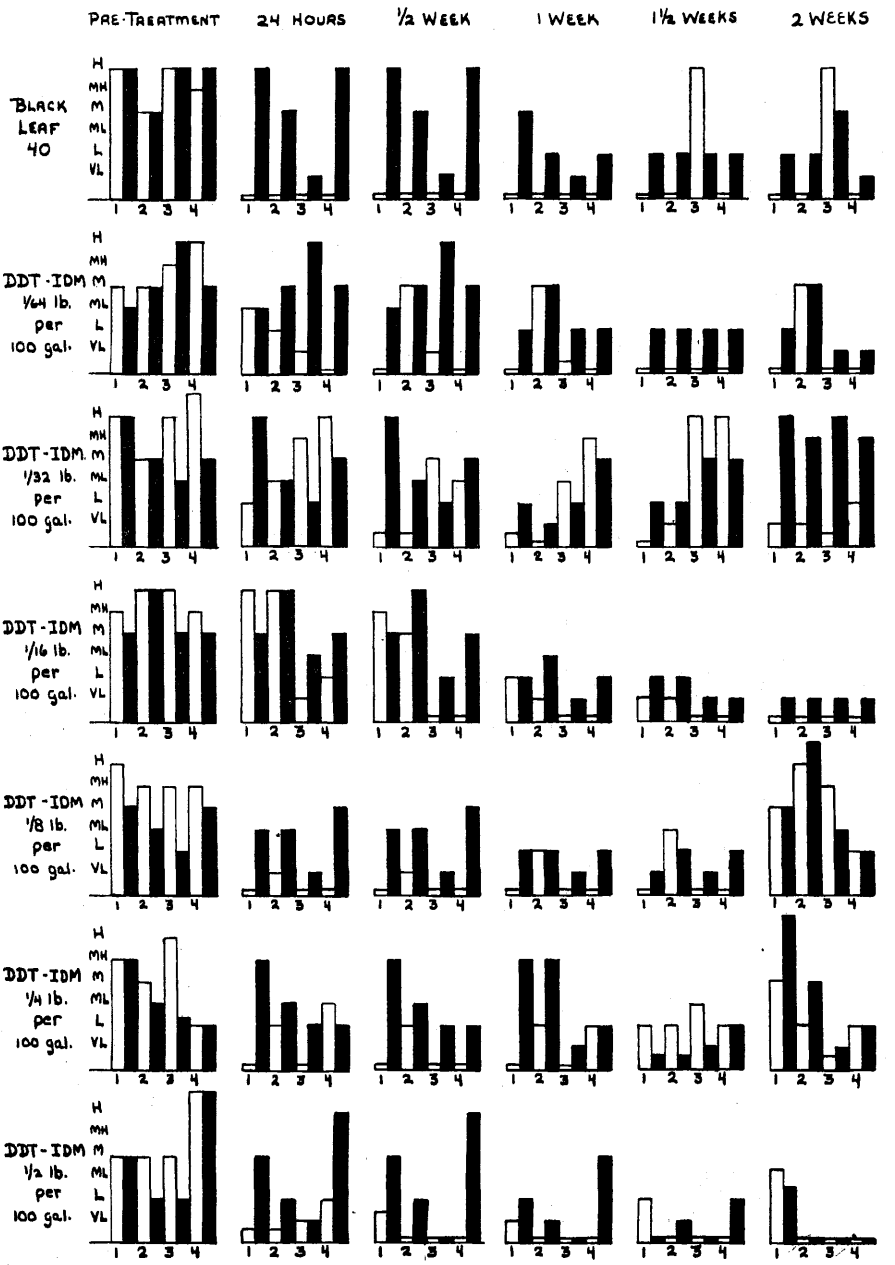
FIELD EXPERIMENT 1—PARASITE AND APHID POPULATIONS

Black=parasite, *A. testaceipes;* white=aphid, *A. maidis.* H= heavy, MH=medium heavy, M=medium, ML=medium low, L=low, VL=very low. Replicated plots are numbered 1, 2, 3, 4 for each treatment.



FIELD EXPERIMENT 2—DUST PLOTS, PARASITE AND APHID POPULATIONS

Black=parasite, *A. testaceipes;* white=aphid, *A. maidis*. H=heavy, MH=medium heavy, M=medium, ML=medium low, L=low, VL=very low. Replicated plots are numbered 1, 2, 3, 4 for each treatment.



FIELD EXPERIMENT 2—SPRAY PLOTS, PARASITE AND APHIS POPULATIONS

Black=parasite, *A. testaceipes;* white=aphid, *A. maidis.* H=heavy, MH=medium heavy, M=medium, ML=medium low, L=low, VL=very low. Replicated plots are numbered 1, 2, 3, 4 for each treatment.

and twice each week for a period of two weeks. This test was set up late in the season and due to corn harvest in mid-September, of necessity had to be terminated in two weeks.

In regard to the spray plots, Plate III illustrated good aphid control with Black Leaf 40. DDT treatments were at much lower concentrations than those of the previously mentioned experiment. Fair control appears to have been obtained with the highest concentration (½ pound DDT per 100 gallons of spray). In all cases, the parasites were not eradicated but rebuilt populations when the aphid population started to rise.

The dust plots illustrated on Plate II show that a 2% DDT dust and nicotine-rotenone dust were about equally effective aphicides. At concentrations below 2% the aphids reestablishing themselves commenced to rebuild their population. The 4% and especially the 8% dusts nearly eradicated both aphids and parasites within a week.

Laboratory Testing

Methods—

The plan was to set up a laboratory test to resemble field conditions. Corn tassels heavily infested with the corn leaf aphid which were largely parasitized by the braconid, *A. testaceipes*, were located in the field. These were cut and taken to the laboratory. They were then trimmed to fit cages described below, implanted in a can of moist sand, and treated. A pressure type compressed air paint sprayer was used to cover all parts of the plant adequately with DDT. The dosages used are shown on Plate IV.

Four replicates, each consisting of one plant, were used for each treatment. The plants were kept under artificial lights to simulate natural conditions.

Cages—

Cages were constructed of large celluloid strips which were rolled into cylinders and sealed with acetone making a cage eighteen inches high and six inches in diameter. A very fine mesh cheesecloth ceiling was fastened in the cage with acetone. The base consisted of an 8-inch clay flower pot saucer in which a layer of sand was placed.

Data—

Regular inspection of the cages took place each day for a period of two weeks. An actual count of the number of live parasites was made along with a count of the number of dead parasites. Predators were present and their various stages of development were noted along with the aphid host. Figure 3 illustrates the total parasite emergence per cage.

Aphids—

The aphids remained alive and in abundance on the checks for a week with the populations gradually decreasing after that time. Table I shows aphid kill 24 and 48 hours after treatment.

The decreasing size of the aphid population was probably due to adverse environmental conditions. While the experiment was in progress there was a sudden change in the weather. The days became very hot with an average temperature close to 80° F. The laboratory was not air-conditioned and the temperature could not be kept down to a more favorable constant for aphid development.

PARASITES—

Wherein the increase in temperature may have hindered aphid development its effect on the parasite population was the opposite. Parasites emerged in tremendous numbers and were very active.

For a record of the total parasites emerging from each cage see figure 4. The average number of parasites present each day during the period of two weeks has been plotted graphically (Plate IV). This series of graphs shows parasites emerging throughout the cages in all treatments. The lowest DDT concentration (1/64 lb. DDT/100 gal.) shows a decidedly lower parasite emergence than the control. But, the highest concentration (2 lb. DDT/100 gal.), although low, also shows continued emergence throughout most of the period.

TABLE I

APHID MORTALITY—LABORATORY DDT TESTS

TREATMENT	CAGE							
	24 hours				48 hours			
	A	*B*	*C*	*D*	*A*	*B*	*C*	*D*
1. Control	O	O	O	O	O	O	O	O
2. DDT 1/64 lb./100 gal	O	VL—	VL—	VL—	O	VL—	VL—	VL—
3. DDT 1/32 lb./100 gal	VL—	VL—	VL—	VL—	VL—	VL	VL—	VL—
4. DDT 1/16 lb./100 gal	VL—	VL—	VL—	VL—	VL—	VL—	VL—	VL—
5. DDT 1/8 lb./100 gal	VL—	VL—	VL—	VL—	VL—	VL—	VL—	VL—
6. DDT 1/4 lb./100 gal	VL—	VL—	VL—	VL—	VL	VL	VL	VL
7. DDT 1/2 lb./100 gal	M	L	MH	M	M	ML	MH	M
8. DDT 1 lb./100 gal	M	H	H	M	MH	H	H	MH
9. DDT 2 lb./100 gal	H	H	H	H	VH	VH	H	VH

A, B, C, D=Cage replicate; O=Zero, VL=Very low, L=Low, ML=Medium low, M=Medium, MH=Medium heavy, H=Heavy, VH=Very heavy mortality, VL— =Less than VL.

It seems quite significant that a similar curve for all treatments should be shown by this series of graphs. The emergence reaches a peak and declines, falling down very low and then commences to rise again and reaches another peak in 6 to 7 days. From these comparisons and the fact that this parasite may complete its life cycle in 7–15 days (Webster and Phillips, 1912), it seems logical that the parasites surviving treatment were able to mate and oviposit with the resulting offspring emerging as adults at the time of the second peak shown on the graphs.

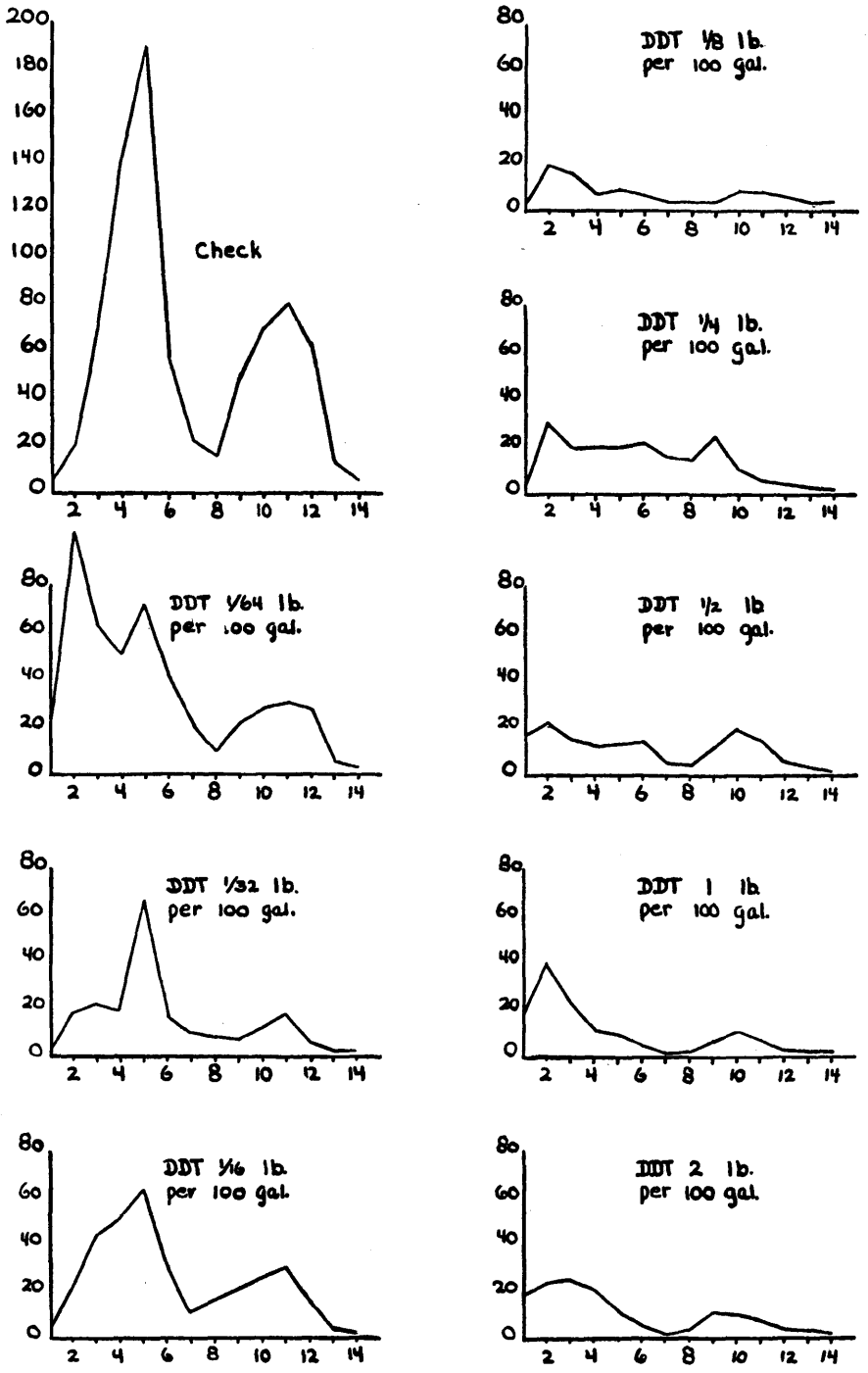
Certain paralytic actions were noted to occur to some of the parasites in cages treated with concentrations of one-fourth pound of DDT per hundred gallons and higher. Parasites would emerge, fly around, and as the data on Plate IV indicates, some would mate and oviposit. Others, as they walked on DDT treated leaves developed nervous reactions characterized by acute twitching of the legs and a gradual loss of equilibrium.

The number of moribund adult parasites increased rapidly in the higher concentrations of DDT. Parasites observed soon after emergence appeared normal until they had walked on the treated surface of the leaves for a short time.

PREDATORS—

In at least one cage of each treatment (concentrations of one pound of DDT per 100 gallons of spray and under) examples of the following occurred.

1. Coccinellid larvae pupated and emerged as adults.



LABORATORY EXPERIMENT

Comparison of Parasite Emergence. The average total living parasites present in the four cages for each treatment is plotted per day as the ordinate; the days being the abcissa.

2. In one cage (DDT ⅛ lb./100 gal.) 5 coccinellid pupae emerged as adults. One pair was observed mating, and eggs were laid.
3. Aphis lions emerged as adult lacewings.
4. Syrphid larvae pupated and emerged as flies.

These observations were only scattered occurrences throughout the cages; consequently, significant conclusions cannot be drawn from them.

SUMMARY

The biology of the corn leaf aphid, *Aphis maidis*, and its parasite, *Aphidius testaceipes*, is briefly reviewed. Field and laboratory experiments are reported of aphid infested field corn plants treated with DDT.

Population studies were made of the aphid and its parasite. A few observations on predators are listed.

In field tests, data taken 24 hours after treatment showed that DDT sprays were more effective against the corn leaf aphid than a nicotine-rotenone dust. One week after treatment nicotine-rotenone dust plots showed the same relative number of aphids killed as did DDT plots, but a lower relative number of parasites killed. One treatment of DDT did not eradicate the parasites unless the aphids were eliminated.

Further observations indicated that:

(1) *A testaceipes* was susceptible to DDT at the lowest concentration used (¼ pounds DDT per 100 gallons).
(2) *A. testaceipes* was not eradicated at the highest concentrations used (2 pounds DDT per 100 gallons) but emergence was greatly reduced.
(3) Laboratory experiments with *A. testaceipes* showed a similar emergence curve for all treatments. The parasite emergence reached a peak, declined nearly to zero and then rose to another peak in six to seven days. This parasite may complete a life cycle in six to seven days. This indicates that parasites surviving DDT treatment, emerged as adults, mated, and oviposited in DDT treated aphids. The resulting offspring of the parasites were able to complete another cycle.

LITERATURE

Annand, P. N., et al., 1944. Tests Conducted by the Bureau of Entomology and Plant Quarantine to Appraise the Usefulness of DDT as an Insecticide. Jour. Econ. Ent., 37: 125–129.

Cutright, Clifford Reginald. 1922. Notes on Aphid Predators. Thesis presented for the degree of Master of Science, Dept. of Zool. and Ent., Ohio State University.

Elmore, J. C., and R. E. Campbell. 1943. Aphid Increase and Plant Injury Following the Use of Calcium Arsenate on Peppers. Jour. Econ. Ent. 36: 853–856, 4 refs., Menasha, Wis., (R. A. E. 32: 269–270, 1944).

Guyton, Thomas Lee. 1924. A Taxonomic, Ecologic, and Economic Study of Ohio Aphididae. Ohio Jour. Sci. 24: 1–30.

Howard, N. F. 1944. Field Experiments with DDT Against the Potato Leaf Hopper and the Turnip Aphid. Jour. Econ. Ent. 37: 152.

Metcalf, C. L., and W. P. Flint. 1939. Destructive and Useful Insects. McGraw-Hill Book Co., Inc., New York.

Michelbacker, A. E., and Clark Swanson. 1944. Factors Influencing Control of the Walnut Aphid. Jour. Econ. Ent. 38: 127–128.

Peterson, Alvah. 1946. Laboratory Tests Showing the Effect of DDT on Several Important Parasitic Insects. Ohio Jour. of Sci. 46: 323–326.

Ripper, W. E. 1944. Biological Control as a Supplement to Chemical Control of Insect Pests. Nature, 153, No. 3885, pp. 448–452, 2 figs., London, (R. A. E. 32: 333–334).

Stevenson, W. A., Louis Sheets, and J. M. Breazeale. 1944. Tests with DDT Against Pentatomids, Mirids, the Bollworm, and the Cotton Aphids. Jour. Econ. Ent., 37: 143.

Walton, R. R., and F. E. Whitehead. 1944. Effects of Nicotine Dust on the Melon Aphis and Its Natural Enemies. Jour. Econ. Ent., 37: 310–311.

Webster, F. M., and W. J. Phillips. 1912. The Spring Grain-Aphis or "Green Bug." U. S. D. A., Bur. of Ent., Bull. 110.