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A DIGEST OF THE LITERATURE ON DDT THROUGH APRIL 30, 1944

by

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INTRODUCTION

The purpose of this digest is to abstract the information contained in the 174 publications listed in a bibliography on DDT that was issued by this Bureau in June 1944. Many of these accounts appeared in periodicals not readily available to entomologists interested in chemical methods of insect control. It is believed that the issuance of this digest will be helpful to all persons having an interest in the development of control measures for injurious insects or in the manufacture of DDT. The numbers in parentheses refer to the publications listed in the bibliography mentioned.

Information on the insecticidal value of proprietary products is not usually given out by the Bureau of Entomology and Plant Quarantine. However, the urgent need to find substitutes for insecticides of which the available supplies are insufficient to meet the requirements has made it desirable to test materials that were thought promising or available, including those covered by private patents or protected by

trade-mark names. DDT, or 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane, is one of the chemical compounds tested in recent months, the use of which as an insecticide is patented. Brief reports on preliminary tests at the various laboratories of the Bureau were published in the February 1944 issue of the Journal of Economic Entomology (51, 60, 61).

Because of the successful large-scale use of dusts containing DDT in delousing civilians in Naples and North Africa and its adoption by the Army for use in louse powder, it has received wide publicity in the popular press, over the radio, and on the screen. The interest of the public has been aroused in its possibilities for control of insects commonly found in houses, gardens, and orchards. This digest of the published information on the use of DDT in insecticidal combinations provides a medium for determining what the literature contains on this subject up to April 30, 1944.

A large number of nontechnical, or popular, references, which ordinarily are not included in a technical review, are added in order to present a complete historical record of the subject. The general public has obtained its information on DDT largely from anonymous and other popular articles, some of which contain erroneous or inadequate information. Since most of the statements in the popular press are based upon the technical reports of experimental work, in this digest such references containing similar statements have been grouped and designated as nontechnical references, in order that readers may distinguish them from the original articles, and evaluate them accordingly.

It should also be emphasized that most of the testing of DDT insecticides reported in this digest has been done under laboratory and small-field-plot conditions. The results should therefore be considered as preliminary and subject to modification as the investigations proceed.

At present the Bureau of Entomology and Plant Quarantine does not recommend DDT insecticides for the control of any species of insects injurious to agricultural crops. The insecticidal action of DDT is not universal; that is, while it is highly toxic to many species of insects, it is relatively nontoxic to others. Before it can be recommended to farmers, many more tests must be conducted to determine whether it injures plants; to establish the tolerance for DDT residues on fruits and vegetables; to learn the minimum lethal dose to a large number of insects, injurious and beneficial; to learn how it is best applied and best prepared for different types of application; and to find out its stability when mixed with various diluents, wetters, spreaders, and stickers. All this will take considerable time.

NOMENCLATURE AND CHEMISTRY

Dichlorodiphenyltrichloroethane, from which the designation DDT is derived, can exist in many isomeric forms depending upon the position of the chlorine substituents. The product made by condensing monochlorobenzene and chloral, according to the process originally described by Zeidler (174), consists largely of 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane, some of the ortho-para' isomer, and other substances. This product is known as technical DDT and is of somewhat variable composition depending on the temperature and other conditions during its synthesis. A refined grade of DDT, which consists almost wholly of 2,2-bis(p-chlorophenyl)-1,1,1-trichloroethane, is designated as pure DDT.

DDT is an ingredient of several trade-marked insecticides, such as GNB-A, GNB-A-DDT, Neocid, Gesarol, and Gesarex. These trade-marks are the property of the Geigy Company (12, 82-86). It is incorrect, as some writers have done, to state that DDT and Gesarol are synonymous. DDT is a constituent of Gesarol just as nicotine is a constituent of Black Leaf 40.

Before DDT was suggested in the summer of 1943 as a suitable abbreviation for dichlorodiphenyltrichloroethane, the active ingredient of Gesarol from Switzerland was designated GNB, meaning Gesarol-Neocid base (57). The product made in the United States was called GNB-A. DDT has also been referred to as "DDT concentrate" and "Gesarol concentrate."

Following Zeidler's (174) description of its synthesis in 1874 no further mention of this compound is found in the literature until 1942. In that year a British patent assigned to J. R. Geigy A.-G. (81), was issued which states that p,p'-dichlorodiphenyltrichloroethane may be produced as follows:

"225 parts of chlorobenzene are mixed with 147 parts of chloral or the corresponding amount of chloralhydrate and then 1000 parts of sulphuric acid monohydrate are added. Whilst stirring well the temperature rises to 80 C. and then sinks slowly down to room temperature, the mass then containing solid parts. It is poured into a great deal of water, whereupon the product separates in solid form. It is well washed and crystallized from ethyl alcohol forming fine white crystals, having a weak fruit-like odour."

The pure para, para' compound melts at 107°-108°C., but commercial DDT is acceptable to the Army if it has a setting point of not less than 88°. 190.4°F

DDT is insoluble in water but is readily soluble in organic solvents, such as toluene, chloroform, tetrachloroethane, butyl acetate, ethyl acetate, acetone, ethyl alcohol, and methyl cyclohexanol (80).

The mixtures of alkylated naphthalenes sold as Velsicols AR-50 and AR-60 (158) are also good solvents for DDT, even at 0 °C.

The use of zinc chloride in place of sulfuric acid as a condensing agent in the synthesis of DDT has been tried by a student at the

Fresno (Calif.) State College.--Anon. (37).

The Association of Official Agricultural Chemists at its 1943 meeting recommended that DDT be studied (92).

COMMERCIAL PRODUCTION

DDT was first manufactured in the United States in 1943 at the two plants of the Cincinnati Chemical Works, a subsidiary of the Geigy Company (5). Early in 1944 E. I. du Pont de Nemours and Company (19, 20, 21, 29, 31, 38, 44, 49, 109, 120, 153), Merck (23, 26, 31, 45, 46, 49, 120), and the Hercules Powder Company (25, 28, 31, 49, 120) began its manufacture.

DDT has been under allocation by the War Production Board (124, 156) since January 1, 1944, and the supplies have gone to the Army and Navy. None is available for civilian use (24, 54).

PHARMACOLOGY

The effect of DDT on man and other warm-blooded animals has been investigated by three groups of pharmacologists - namely, the U. S. Food and Drug Administration, the U. S. Public Health Service, and the Kettering Laboratory of Applied Physiology of the University of Cincinnati, the last mentioned being sponsored by the Geigy Company. Because of war restrictions none of the results of these pharmacological investigations have been published. However, entomologists engaged in testing the insecticidal possibilities of DDT have made the following observations on its effect on man and other warm-blooded animals:

No deleterious effects were noted from the handling of DDT or from the breathing of the atomized spray.--Tenhet (151).

None of the dogs treated with DDT dusts and emulsions showed any ill effects from the treatment.--Gouck and Smith (90).

None of the dogs dusted with 4 or 5 percent of DDT in pyrophyllite showed any ill effects from the treatment.--Lindquist, Madden, and Knipling (108).

DDT even in concentrated emulsions apparently had no effect upon the fiber or skin of goats.--Babcock (64).

The ears of 303 range cattle were treated with mixtures containing 2 and 5 percent of DDT for destruction of ticks with no apparent injury to the animals.--Rude and Smith (130).

DDT, administered for 10 days to mice, 500 mg., and to rabbits, 100 mg. per kilogram of body weight, produced no ill effects. Two cows and 6 sheep were fed grass sprayed with 1-percent DDT solution for 1 week, with not the slightest disturbance in their health. The preparation was tolerated also in a 2-percent emulsion, as a dipping solution of nursing sheep and their lambs, without any reaction. The repeated application of a 5-percent solution to the cornea of a rabbit produced no injurious phenomenon during 7 days of observation.--Schmid (134).

In addition the effect of DDT on man is noted in various nontechnical articles:

In powdered form (as louse powder) it appears to be harmless to human skin (7, 15, 20, 30, 56).

For use as an insecticide DDT is harmless to humans and warm-blooded animals (11, 13, 16, 18, 33, 41, 47, 118, 162, 163, 164).

The question of cumulative effects has not yet been answered. It is reported as being somewhere between three and five times as toxic as phenol when taken by mouth (56).

It is distinctly toxic to higher animals when taken by mouth (8, 9).

DDT is poisonous to human beings (32, 91).

EFFECT ON PLANTS

Alfalfa. No burning of foliage was observed following the application of a 50-50 DDT-pyrophyllite dust.--Wilson (171).

Apple. Single applications of the following sprays (pounds per 100 gallons) with a hand sprayer on young Rome apple trees growing outdoors gave the following results: DDT 4 plus pyrophyllite 4, no injury; DDT 3 plus bordeaux (4-8-100), moderate injury; DDT 3 plus wettable sulfur 6 plus hydrated lime 6, no injury.--Siegler (139).

No injury occurred on any of the 11 Winesap trees that had been sprayed with DDT (1.5 pounds per 100 gallons), but all the Grimes Golden trees developed injury which may have been caused by the DDT. Irregular dead patches developed between the veins of nearly 25 percent of the leaves, which turned yellow or dropped. All the foliage on these trees gradually became a lighter green than that on unsprayed trees. There was no association between the location of visible deposits of DDT and the injured areas. The injury appeared on most of the trees by August 24, but on 2 trees that had been sprayed with nicotine bentonite prior to July 6 the injury did not develop until later. By October 1 the leaf loss on all 9 trees approximated 75 percent, compared with a 10 percent loss on unsprayed trees. The injury may have been caused, or aggravated, by the increased mite population and extremely hot, dry weather which prevailed between July 6 and September 2.

The injury was as serious on trees that received two applications of DDT at 1 pound per 100 gallons, the second on July 27, as on one tree that was given five applications, the last on August 12. Until the phytocidal effect of this material on all varieties can be investigated under different climatic conditions, it should be used with caution.--Steiner, Arnold, and Summerland (147).

Burning of apple foliage was noticeable only when 3 or 4 percent of Gesarol was used, whereas the normal strength of 1 percent in no case produced any burning effect.--Wiesmann (164).

Beans. A spray suspension of 8 pounds of 5-percent DDT per 100 gallons of water in two applications 7 days apart and two applications of a 1-percent suspension of DDT concentrate caused no injury to young plants.--Swingle and Mayer (149).

Bean plants were not injured by 3 or 10 percent DDT-pyrophyllite dusts.--Harries (93).

Aerosol mixtures containing 2 percent of DDT (with and without 4 percent of orthodichlorobenzene, in methyl chloride) did not injure bean plants. No injury was apparent following the application of a spray containing 4 pounds of 5-percent DDT per 100 gallons of water.--Weigel (159).

Citrus. No plant injury was observed following the spraying of orange and lemon trees with light-medium grade petroleum spray oil or with kerosene, each of which contained GNB-A.--Lindgren and Boyce (104).

No injury to tender lemon leaves has been detected from Gesarol dusts. In one instance, injury to very tender lemon leaves followed an application of a Gesarol emulsion containing 0.2 percent by weight of Gesarol [DDT, not Gesarol, was used.--R.C.R.]. It was emulsified in water with trichloroethylene, oleic acid, and potassium hydroxide.--McGregor (111).

Coleus. Slight injury to a coleus cutting was caused by the application of aerosol mixtures containing 2 percent of DDT and 4 percent of orthodichlorobenzene in methyl chloride.--Weigel (159).

Collard. Same as on beans.--Swingle and Mayer (149).

Corn. Tolerance tests conducted in the field at rates of 2, 4, 6, and 8 pounds of 5-percent DDT per 100 gallons of water previous to the regular spraying season showed no injury to the corn plant at any concentration.--Questel (127, 128).

Gladiolus. On gladiolus foliage DDT spray (7.5 pounds of 5-percent DDT per 100 gallons) with or without brown sugar left a slight white deposit and apparently caused scattered rusty-brown spots. The oil emulsion containing DDT (1 percent in deodorized kerosene, emulsified in water at the rate of 4 gallons to 100 gallons of spray) caused severe yellowing and death of many plants of the variety Flaming Sword and less severe injury to La Paloma. The oil emulsion alone seemed to cause more injury than did that containing DDT.--Smith (145).

Grape. A test of DDT, 4 pounds per 100 gallons, on Concord grape showed severe foliage injury.--Siegler (139).

There was no evidence of injury to fruit and foliage following application of DDT, 1 pound per 100 gallons.--Fleming and Chisholm (78).

Onion. No ill effects were observed on onion foliage, although a slight white deposit was left by the treatments with DDT alone and with brown sugar. DDT was applied at the rate of 7.5 pounds of 5-percent DDT per 100 gallons.--Smith (145).

Peach. Single applications of the following sprays (pounds per 100 gallons) with a hand sprayer on Elberta peach trees growing outdoors gave the following results: DDT 4 plus pyrophyllite 4, moderate injury; DDT 3 plus wettable sulfur 6 plus hydrated lime 6, no injury.--Siegler (139).

There was no evidence of injury to fruit and foliage following one application of DDT, 1 pound per 100 gallons.--Fleming and Chisholm (78).

No injury to the fruit or foliage of four varieties of peaches (Raritan Rose, Cumberland, Triogen, and Golden East) was observed from the one spray application of DDT.--Driggers (77), Martin (115).

Peas. Effect of 5-percent DDT same as on beans.--Swingle and Mayer (149).

Pea plants were not injured by pyrophyllite dusts containing 10 percent of DDT.--Harries (95).

Plum. Same as on peach.--Fleming and Chisholm (78).

Potato. Two applications of a 1-percent suspension of DDT caused no injury to potato plants.--Swingle and Mayer (149).

A dust of 3-percent DDT in pyrophyllite caused slight yellowing of potato leaves within 4 days after treatment, whereas the sprays caused no injury.--Weigel (159).

Pumpkin. Same as on beans.--Swingle and Mayer (149).

Radish. DDT applied as an aerosol from methyl chloride solution caused no injury.--Weigel (159).

Snapdragon. No injury was apparent following the application of 4 pounds of 5-percent DDT per 100 gallons of water.--Weigel (159).

Swiss chard. Same as on beans.--Swingle and Mayer (149).

Miscellaneous plants. Preliminary observations on DDT indicated that it might be noninjurious to vegetation harboring ticks.--Smith and Gouck (143).

DDT was tested for injury to the foliage of upland cotton, cowpea, peanut, soybean, tomato, velvetbean, and 11 species of herbaceous flowers and weeds. Both a 50-50 DDT-pyrophyllite dust and a spray containing 0.5 pound of DDT and 3 pints of raw linseed oil per 100 gallons of water were used. No rain occurred for 10 days or more after the applications, and no foliage injury was observed on any of these plants.--Young (172).

Nontechnical reference

DDT does not seem to be harmful to plants (56).

INSECTICIDAL VALUE

DDT has been tested against 132 identified species of insects and other arthropods belonging to 13 orders and 63 families.

ORTHOPTERA

Acrididae

Camula pellucida (Scudd.), the clear-winged grasshopper
Melanoplus bivittatus (Say), the two-striped grasshopper
Melanoplus devastator (Scudd.), the devastating grasshopper

Field trials were conducted against infestations consisting of 10 to 30 adults per square yard in alfalfa in Nevada and California. A 50-percent DDT-pyrophyllite dust killed 90 percent in 24 hours and a 10-percent dust killed only 15 percent in dense alfalfa and none in the open. Bait containing 3 pounds of DDT in 50-percent DDT-pyrophyllite mixture per 100 pounds of bran was equal in efficiency to bait containing 1 to 1½ quarts of sodium arsenite (32 percent of As_2O_3) to 100 pounds of carrier. In other field tests this DDT bait was 24 percent more effective in green alfalfa than 3 pounds of sodium fluosilicate. The DDT bait killed the grasshoppers much more quickly than sodium arsenite bait, the rapidity of its action resembling that of sodium fluosilicate.--Wilson (171).

Melanoplus mexicanus mexicanus (Sauss.), the lesser migratory grasshopper
Melanoplus femur-rubrum (Deg.), the red-legged grasshopper

M. mexicanus mexicanus was the most abundant species tested, but small numbers of M. bivittatus and M. femur-rubrum were also present. In cage tests baits prepared with DDT (4 pounds per 100 pounds of bran) were definitely toxic but were inferior to the sodium fluosilicate bait applied at the same rate. The DDT bait killed 33 percent in 1 day and 57 percent in 3 days, while the sodium fluosilicate bait killed 78 percent in 1 day and 100 percent in 3 days. When DDT was dissolved in acetone before being mixed with bran, the mortality was greater than when dry DDT was mixed with bran; 4 pounds of DDT in acetone in 100 pounds of bran killed 35 percent in 1 day and 83 percent in 3 days.--Hinman (96).

Blattidae

Blattella germanica (L.), the German cockroach

Four insecticides were tested as dusts, the base of which was a 50-50 mixture of talc and soybean flour--sodium fluoride (C.P.), DDT (C.P.), derris (5 percent rotenone), and pyrethrum (1 percent pyrethrins). The roaches were tested in 1-gallon glass jars, 20 to 30 adults 10 weeks old being put into each jar. The insides of the jars were dusted thoroughly and the excess dust was then shaken out. Pre-

liminary determinations had shown that approximately 140 mg. of dust was required to cover one jar, or about 0.8 mg. per square inch. Seven percent of DDT and 33 percent of sodium fluoride were the minimum concentrations required to kill 100 percent in 48 hours. DDT appears therefore to be about five times as toxic to roaches as is sodium fluoride. Dusts containing 33 percent of derris or pyrethrum gave 30 and 90 percent kill in 48 hours, respectively. Thus, DDT is vastly more toxic to roaches than are sodium fluoride, derris, and pyrethrum.--Ginsburg (88).

When DDT (100 percent), mixed with dog biscuit or mouse food (1-100), was fed for 3 weeks to cockroaches, all the German cockroaches died. Other tests were made with a 50-50 mixture of dog biscuit and mouse food to which was added DDT at 1 gm. to 50, 100, 500, and 1,000 gm. of the food mixture. Five adult roaches (German and American) were placed in each of 20 jars. After 10 days 6, 14, 25, and 25 German roaches were found alive with the respective mixtures.--Morrill (116).

In laboratory tests 5 percent of DDT in talc was applied as a band an inch wide across the center of a pan 14 inches square. Roaches exposed continuously to this dust were all killed within 48 hours. Of roaches allowed to run once across this band 30 and 40 percent were killed in 96 hours. In practical tests in Army mess halls a 5-percent spray, made by dissolving DDT in an equal weight of cyclohexanone and mixing 1 gallon of this stock with 12.5 gallons of kerosene, was used in two buildings. A water emulsion containing 5 percent of DDT, 15 percent of xylene, and 5 percent of Triton NE was sprayed in a third building. Six buildings were dusted, four with 25 percent of DDT mixed with talc and two with 10 percent of DDT in talc. The sprays applied were 18 to 95 gm. of DDT per 100 square feet and the dusts 19 to 29 gm. Large numbers of cockroaches were killed by all these treatments. Almost instant results were obtained with the sprays, whereas delayed action was observed in the case of the dusts. In one building 2,000 dead roaches were on the floor within 30 minutes after spraying. The dusts were also highly toxic, and similar results were obtained with the 25- and 10-percent mixtures. In each of three buildings at least 4,000 dead adults and large nymphs were seen on the floor. Complete eradication of these pests was not obtained in any of these buildings, but their populations were satisfactorily decreased, with the greatest reductions in the buildings that were dusted. A theater which had difficulty in controlling roaches was sprayed at the rate of 1 gallon to 300 seats with a water emulsion containing 2.5 percent of DDT, 5 percent of xylene, and 0.1 percent of Triton NE. Fourteen days later the population was noticeably decreased.--Gahan and Knipling (79).

In preliminary tests by the pendulum method, a deodorized kerosene spray containing 2 percent (w./v.) of DDT applied to the dorsal surface of German roaches was less effective than a similar spray containing 0.4 percent (w./v.) of pyrethrins. A proprietary powder containing 3 percent of DDT, scattered over the floor of glass cylinders, caused

mortalities approximately equal to that obtained with a pyrethrum powder containing 0.66 percent of pyrethrins. A dust containing 10 percent of DDT in pyrophyllite was less effective than a finely ground commercial grade (95 percent) of sodium fluoride, but on the basis of the amount of toxicant in each powder the DDT was more effective.--McGovran, Richardson, and Piquett (110).

Periplaneta americana (L.), the American cockroach

DDT mixed with bait (1 to 100) was fed for 3 weeks to 50 cockroaches (10 in each of 5 jars) all but 1 of which died. In other tests the food consisted of dog biscuit and mouse food (50-50) to which was added DDT at rates of 1 gm. to 50, 100, 500, and 1,000 gm. of food mixture. Five adult roaches were put in each of 20 jars and each rate was replicated five times. Ten days after the respective mixtures had been given them 1, 4, 7, and 20 roaches were found alive.--Morrill (116).

In laboratory tests, when 5 percent of DDT in talc was applied on a band an inch wide across the center of a pen 14 inches square, all the roaches exposed were killed within 48 hours. DDT in concentrations as low as 0.1 percent was completely effective in 96 hours. When 5 percent DDT and undiluted sodium fluoride were compared in pens 10 feet square, all roaches that had been placed with DDT were on their backs within 48 hours and 24 hours later were dead, while only 60 percent of those placed with sodium fluoride were dead after 144 hours. In a more severe test in which roaches were allowed to run across a narrow band of 5-percent DDT, mortalities of 100 percent in 48 and 72 hours were obtained. A dust containing 0.1 percent of DDT was ineffective. In a practical test in a dairy a spray containing 2 percent of DDT, 2 percent of Nopco 1216, and 10 percent of acetone was applied to control flies. Two days later 982 dead and dying cockroaches were counted and two weeks later dead roaches were still being found on the floor.--Gahan and Knipling (79).

Deodorized kerosene containing 2 percent (w./v.) of DDT was ineffective when tested by the pendulum method. When this spray was tested by confining roaches in a rising mist of spray, it was less effective than a similar spray containing 0.2 percent (w./v.) of pyrethrins. The roaches were not knocked down rapidly by the DDT sprays. A 3-percent DDT powder was less effective than a pyrethrum powder containing 0.66 percent of pyrethrins. A dust containing 10 percent of DDT in pyrophyllite was less effective than a finely ground commercial grade (95 percent) of sodium fluoride, but on the basis of the amount of toxicant in each powder the DDT was more effective.--McGovran, Richardson, and Piquett (110).

In laboratory tests 100 percent mortality was obtained in 18 hours when adult American roaches were confined on a surface treated with a 5-percent DDT dust, and in 48 hours when a 1-percent dust was used. A 10-percent dilution of sodium fluoride caused no mortality, and 5 percent of pyrethrum (1.2 percent of pyrethrins) killed only 65 percent in 72 hours. When large nymphs were confined for 3 days

on a deposit from a 1-percent spray suspension of DDT concentrate, 92 percent mortality was obtained.--Swingle and Mayer (149).

Nontechnical references on cockroaches

DDT is effective against the American cockroach (55) but not against the German cockroach (55, 91, 129).

DDT has been found toxic to cockroaches (7, 18, 20, 38, 56, 72, 122, 123, 129, 154).

ISOPTERA

Rhinotermitidae

Reticulitermes flavipes (Kol.), the subterranean termite

When termites were confined in an artificial chamber dusted lightly with the 5-percent DDT mixture, they succumbed within 2 days. In field tests, however, they avoided it wherever possible. Pieces of paper toweling, strips of fabric, and small pine plant markers treated with 1 or 5 percent DDT in acetone and exposed out of doors were attacked little or not at all, although owing to the severe drought the results were not conclusive.--St. George (132).

Reticulitermes sp.

A 3-percent DDT dust mixed with sand (1-10,000) caused no mortality within 2 days of adult termites placed on the surface of the treated sand. However, the treatment repelled the termites and prevented their entrance into the sand. In 5 days 97 percent were dead, but this mortality must have been caused by excessive exposure to the air.--Swingle and Mayer (149).

Nontechnical references

DDT has been employed successfully against termites (18, 29, 63, 70).

MALLOPHAGA

Trichodectidae

Bovicola caprae (Gurlt), the red goat louse

Trichodectes hermsi Kellogg and Nakayama, the yellow goat louse

Trichodectes limbatus Gervais

Angora goats infested with these lice were dipped in 0.3 and 0.6 percent of DDT in a water emulsion. In every case all the lice were killed soon after hatching and no reinfestation developed in 26 days. In another test Angora goats were dipped in water emulsions containing 0.3, 0.15, 0.07, and 0.04 percent of DDT. All concentrations killed all red and yellow lice, and there was no reinfestation in 25 days.

Tests with DDT combined with wettable sulfur in dips suggested that neither chemical influenced the effectiveness of the other. These limited tests indicated that a single dipping in DDT may serve as an effective control for goat lice. These biting lice (Mallophaga) are more susceptible than are the sucking lice (Anoplura). The DDT, even in concentrated emulsions, apparently had no effect upon the fiber or skin of the animals.--Babcock (64).

Nontechnical references

DDT has been found effective against goat lice (59, 154).

Trichodectes equi (L.), the horse biting-louse

Geigy's preparation No. 1859 [contains DDT] in powder form proved to be a satisfactory remedy for the destruction of lice and nits on horses.--Schmid (134).

Neocidol, either as a powder or an emulsion, does not irritate the skin of sensitive animals and kills all lice and nits within 2 days. About 150 to 300 gm. of the powder is required per horse.--Schneider (135).

THYSANOPTERA

Thripidae

Frankliniella fusca (Hinds), the tobacco thrips

In preliminary plot tests a 3-percent DDT-pyrophyllite dust was very much superior to a 2-percent dinitrocyclohexylphenol-sulfur dust for control of this thrips on cotton.--Shiller and Richmond (138).

Heliothrips haemorrhoidalis (Bouche), the greenhouse thrips

Scirtothrips citri (Moult.), the citrus thrips

DDT sprays and dusts have given promising results in field tests against these thrips.--Boyce (66, 67).

Emulsions of Gesarol [DDT, not Gesarol, was used.] carrying 2, 0.5, and 0.2 percent by weight of this compound, applied to lemon leaves in laboratory tests, killed all citrus thrips in 1 day when the insects were placed on freshly dried residues, and in 1 or 2 days on residues 1 day old. When adults were placed on lemon leaves dusted with Gesarol and talc (2+98) at the rate of 1.4, 3.4, and 9.8 micrograms per square centimeter of leaf surface, the mortality was 91 to 100 percent in 24 hours, and 100 percent in 41 to 48 hours. A dust containing 20 percent of Gesarol in talc, applied so as to deposit 98 micrograms of Gesarol per square centimeter, killed all adult thrips in 4 hours.--McGregor (111).

Taeniothrips simplex (Morison), the gladiolus thrips

Sprays containing 7.5 pounds of 5-percent DDT, with and without 4

pounds of brown sugar, and a spray containing 1 percent of DDT in 4 gallons of deodorized kerosene and 8 pounds of soap, were compared with a standard tartar emetic spray (2 pounds plus brown sugar 4 pounds), all quantities per 100 gallons of water. The tartar emetic-brown sugar spray was superior in all treatments. The DDT-brown sugar spray was inferior to the DDT alone or to the DDT-oil emulsion.--Smith (145).

Thrips tabaci Lind., the onion thrips

Same as for Frankliniella fusca (Hinds).

Same as for Taeniothrips simplex (Morison).

Unidentified thrips

Gesarol is used against thrips.--Kotte (103).

HOMOPTERA

Aphididae

Aphis gossypii Glov., the cotton aphid

A 2-percent DDT-pyrophyllite dust killed 15.4 percent of aphids in laboratory tests as compared with 81 percent in similar tests with 2-percent nicotine dusts.--Ivy (101).

In a small plot of cotton dusted with 2-percent DDT, temperature 87°F., 41 percent of the aphids were dead after 48 hours. A 2-percent free-nicotine dust killed 76 percent. In another plot, temperature 82°F., the DDT dust killed only 5 percent of the aphids, as compared with 86 percent for nicotine.--Stevenson, Sheets, and Breazeale (148).

Aphis pruni (= A. prunifoliae Fitch), the prune aphid

The southern sides of six plum trees were sprayed with 1-percent Gesarol mixture, while the northern sides were left unsprayed as controls. Later no aphids were found on the treated sides, but they were very numerous on the control sides. Gesarol afforded a lasting protection against the aphids.--Wiesmann (169).

Aphis spireacola Patch, the spirea aphid

A 3-percent DDT dust killed all stages of this aphid on young orange, but not so quickly as did a 0.25-percent nicotine sulfate spray.--Swingle and Mayer (149).

Macrosiphum pisi (Kltb.), the pea aphid

Results on wingless adults in laboratory tests indicated that, in equal concentrations, DDT in pyrophyllite is at least as toxic as rotenone in derris-root mixtures with the same diluent. DDT killed faster than derris. A concentration of DDT as low as 0.0781 percent gave 88 percent mortality of aphids.--Harries (93).

Myzus persicae (Sulz.), the green peach aphid

Radish plants infested with aphids were exposed for $2\frac{1}{2}$ hours in a 16-cubic-foot fumigation chamber in which 34 gm. of an aerosol mixture containing 2 percent by weight of DDT in methyl chloride had been released. After 48 hours 86 percent of the aphids were dead. An aerosol containing 2 percent of DDT and 4 percent of orthodichlorobenzene in methyl chloride killed 98 percent within 3 days. In a greenhouse test a spray containing 4 pounds of 5-percent DDT per 100 gallons of water killed only 38 percent of the treated aphids within 48 hours after treatment. A 3-percent DDT dust killed only 51 percent of the aphids within 4 days.--Weigel (159).

Phorodon humuli (Schrank), the hop aphid

The control of this aphid in Germany with Gesarol is discussed.--Zattler (173).

Rhopalosiphum pseudobrassicae (Davis), the turnip aphid

Small plots of turnips heavily infested with aphids were dusted twice with 1 percent of DDT in pyrophyllite while other plots were dusted with standard insecticides. The DDT mixture was applied at the rate of 119 pounds per acre per application, the derris dust (1 percent rotenone and 2 percent oil) at 98 pounds, and the nicotine sulfate dust (3 percent nicotine) at 65 pounds. The numbers of aphids surviving on four leaf sections after 48 hours were 43 for DDT, 18 for derris, 8 for nicotine, and 412 for the control (undusted).--Howard (98).

Sipha flava Forbes, the yellow sugarcane aphid

Sugarcane dusted four times with a 50-50 DDT-pyrophyllite mixture at the rate of 8 pounds per acre for the control of the sugarcane borer was examined 3 days after each of the last two dustings to determine the effect of DDT on the abundance of the yellow sugarcane aphid. The number of aphid-infested leaves in the DDT plots was about six times as great as in the undusted check plots. The great increase of aphids resulting from the use of DDT would thus be a serious drawback to its use in control of the sugarcane borer.--Ingram (100).

Unidentified aphids

If used with a wetting agent Gesarol is very effective against aphids.--Kotte (103).

Nontechnical references

DDT is effective against aphids (20, 44, 150).

Cicadellidae

Empoasca fabae (Harr.), the potato leafhopper

In experiments on small plots of beans and potatoes a mixture containing 1 percent of DDT, 19 percent of Bancroft clay, and 80 percent of sulfur was as effective as a pyrethrum-sulfur mixture (0.025 percent pyrethrins). Some of the counts showed less than one leafhopper surviving per leaf.--Howard (98).

Peregrinus maidis Ashm., corn leafhopper

A 5-percent DDT dust caused 100 percent mortality of large nymphs infesting a corn leaf within 24 hours. The pyrethrum standard (1.2 percent pyrethrins) diluted to 10 percent in talc gave similar results.--Swingle and Mayer (149).

Coccidae

Aonidiella aurantii (Mask.), the California red scale

In laboratory tests DDT in petroleum spray oils, applied as emulsions, has not only given increased kill of adult females and younger stages over the oils alone, but has been strikingly effective in preventing young crawlers from settling and developing on citrus fruits for as long as 60 days after spraying. Emulsions of xylene or benzene containing DDT had little effect on the adult female scales, but the residue inhibited the settling and development of the young for at least 45 days. Deposits from water suspensions of technical DDT, used at the rate of 2 pounds to 100 gallons of water, inhibited more than 95 percent of the young crawlers from developing on citrus fruits. In many of the tests with DDT-oil sprays the young crawlers were killed before they emerged from beneath the waxy covering of the mother insects. Oil sprays containing DDT plus cube powder or derris extract were also promising.--Lindgren and Boyce (104); Boyce (66, 67); Lindgren, LaDue, and Dow (105). This work is referred to in (32).

Pseudococcus citri (Risso), the citrus mealybug

Mealybugs were exposed for $2\frac{1}{2}$ hours in a 16-cubic-foot fumigation chamber in which 34 gm. of an aerosol mixture containing 2 percent of DDT in methyl chloride had been released. Only 6 percent of the mealybugs on the coleus were killed after 48 hours. In another test with an aerosol containing 2 percent of DDT and 4 percent of orthodichlorobenzene in methyl chloride, only 25 percent of the mealybugs (mostly nymphs) were dead 3 days later. The eggs were unaffected.--Weigel (159).

Membracidae

Stictoccephala festina (Say), the three-cornered alfalfa hopper

Three days after the application of DDT-pyrophyllite dust (1-10) to cabbage plants at the rate of 18 pounds per acre, 1 dead three-cornered alfalfa hopper was observed.--Smith and Harrison (142).

HEMIPTERA

Cimicidae

Cimex lectularius L., the bedbug

Cimex hemipterus (F.), the tropical bedbug

In approximately 1,500 laboratory tests with about 100 materials against a mixed population of these two species, DDT was found to be the most outstanding, with pyrethrum somewhat less effective. No difference in resistance was detected between the two species. In jar tests 5 percent of DDT in a mixture with dimethyl phthalate and acetone and 1 percent of DDT in deodorized kerosene gave complete mortality up to 39 days after application. In order to simulate natural conditions, cages containing miniature mattresses were next used. Spray was applied to the mattress and lower half of the cage at the rate of 100 to 150 mg. per square foot of surface. Fresh bedbugs were introduced weekly after spraying and exposed for 48 hours. In these tests 20 percent of DDT in orthodichlorobenzene applied at the rate of 100 mg. per square foot gave complete mortality after 73 days. A cage receiving this treatment, but scrubbed with hot water and soap 8 days later, gave 100 percent mortality after 78 days. A spray containing 0.5 percent of pyrethrins plus 2 percent of N-isobutylundecylenamide in deodorized kerosene applied at the rate of 2.5 mg. of pyrethrins per square foot gave kills from 60 to 80 percent up to 22 days after treatment and after that time was practically worthless. In practical tests 20 percent of DDT plus 40 percent of orthodichlorobenzene in kerosene applied at the rate of 140 ml. per bed gave 100 percent kill up to the 281st day and 5 percent of DDT in kerosene applied at the rate of 195 ml. per bed killed 100 percent up to the 64th day. In several small tests in Army barracks in Florida 5 percent of DDT in kerosene was effective for several months. In a large-scale practical test involving 80 barracks complete freedom from bedbugs was recorded for nearly 4 months. It was concluded that, from a practical standpoint, 5 percent of DDT in crude kerosene is probably the most satisfactory to use, particularly under military conditions.--Madden, Lindquist. and Knipling (112).

Tests to determine whether insecticidal action can be effected through the blood of the host by oral administration of insecticides were conducted with these two species of bedbugs on rabbits. Mortality as high as 100 percent occurred when the bugs were allowed to feed 3 to 5 hours after DDT was administered to the rabbits in dosages of from 228 to 400 mg. per kilogram of body weight. Pyrethrum extract gave similar results, but the knock-down of the bedbugs was faster.--Lindquist, Knipling, Jones, and Madden (106).

DDT in deodorized kerosene was highly toxic to both species of bedbugs, when applied directly as a contact spray by the turntable method. At a concentration of 0.18 percent in deodorized kerosene DDT was as toxic as the same concentration of pyrethrins, although the lethal effect was not complete until 2 to 4 days after treatment as compared with 1 day for pyrethrum. The DDT sprays appeared to have little effect on

bedbug eggs.--McGovran, Richardson, and Piquett (110).

Nontechnical references

DDT kills bedbugs and bugproofs mattresses for several months (5, 7, 18, 20, 29, 30, 55, 56, 63, 70, 72, 152).

Coreidae

Anasa tristis (Deg.), the squash bug

A 3-percent DDT dust applied to first and fourth instars on pumpkin foliage caused 100 percent mortality in 2 days in laboratory tests. The pyrethrum standard (1.2 percent pyrethrins) gave the same results against fourth instars.--Swingle and Mayer (149).

In insectary cages 10-percent DDT--pyrophyllite dust killed 100 percent of Anasa spp. adults and nymphs in 2 days, in another test 94 percent in 7 days, and in a third test 100 percent in 6 days. Derris (0.75 percent rotenone) killed 96 percent in 7 days.--Harrison (94).

Miridae

Creontiades femoralis Van D.

In cage tests 2-percent DDT-pyrophyllite dust killed all (20) the mirids on cotton in 24 hours.--Stevenson, Sheets, and Breazeale (148).

Halticus bracteatus (Say), a flea hopper

A 3-percent DDT dust gave excellent control in weekly applications to small celery plants in outdoor plot. A commercial pyrethrum dust was relatively ineffective in semiweekly applications. A suspension of 8 pounds of 5-percent DDT in 100 gallons of water also gave excellent control.--Swingle and Mayer (149).

Lygus oblineatus (Say), the tarnished plant bug

In laboratory experiments a 10-percent DDT dust killed 96 percent of the nymphs and 99 percent of the adults in 24 hours, and all were dead in 48 hours.--Hills (95).

Lygus sp.

See Creontiades femoralis.

Pentatomidae

Chlorochroa ligata (Say), the oonchuela in the Southwest

In tests in which screen cages were placed over cotton plants, 5-percent DDT-pyrophyllite dust killed 80 percent and 2-percent dust

killed 66 percent of the adults in 5 days.--Clark (74).

Chlorochroa sayi Stål., the Say stinkbug

In two experiments with the bugs confined in small screen cages, 10-percent DDT dust killed a large percentage, but its action was slow, the mortality not being complete until 4 to 6 days after application.--Hills (95).

In cage tests 2-percent DDT-pyrophyllite dust killed all (29) the bugs tested in 96 hours, but only 10 percent in 24 hours and 80 percent in 48 hours.--Stevenson, Sheets, and Breazeale (148).

Eurydema oleraceum (L.)

Gesarol is used against this bug on truck crops.--Kotte (103).

Euschistus impictiventris Stål, the brown cotton bug

In cage tests 2-percent DDT-pyrophyllite dust killed all (60) the bugs tested in 96 hours but only 50 percent in 24 hours and 80 percent in 48 hours.--Stevenson, Sheets, and Breazeale (148).

Murgantia histrionica (Hahn), the harlequin bug

In laboratory tests a 1-percent DDT dust killed 90 percent of the adults within 2 days. Four other concentrations ranging from 3 to 100 percent as well as the undiluted pyrethrum standard (1.2 percent pyrethrins) gave about the same results.--Swingle and Mayer (149).

Tests conducted in insectary cages showed that both 10-percent DDT-pyrophyllite dust and derris dust (0.75 percent rotenone) killed 100 percent of the adults in 2 days.--Harrison (94).

Nezara viridula (L.), the southern green stinkbug

In cage tests a 3-percent DDT dust killed 86 percent of adults in 3 days, but in two later tests only 75 and 72 percent in 5 days.--Chamberlin (73).

A 10-percent DDT-pyrophyllite dust killed 100 percent of the adults and nymphs in 2 days in one series of laboratory tests but only 76 percent in 4 days in another series.--Harrison (94).

Three days after the application of DDT-pyrophyllite dust (1-10) to cabbage plants at the rate of 18 pounds per acre, 1 live southern green stinkbug was observed.--Smith and Harrison (142).

ANOPLURA

Haematopinidae

Haematopinus eurysternus Nitz., the short-nosed cattle louse

A spray containing 0.5 percent of DDT gave a complete kill of all active stages. It persisted on the hair of the animals long enough to kill the young lice that hatched from the eggs.--United States Bureau of Entomology and Plant Quarantine (154).

Linognathus stenopsis (Burn.), the blue goat louse

Angora goats infested with lice were dipped in water emulsions in strengths of 0.3, 0.15, 0.07, and 0.04 percent of DDT. All blue lice were killed with all concentrations except the 0.04 percent and there was no evidence of a reinfestation in 25 days. Mixtures of DDT and wettable sulfur were also tested.--Babcock (64, 154).

Nontechnical references

DDT has been employed successfully against livestock lice by Agriculture Department researchers (18, 29, 63, 70).

Pediculidae

Pediculus humanus corporis Deg., the body louse

Pediculus humanus humanus L., the head louse

Phthirus pubis (L.), the crab louse

The first sample, a commercial dust [containing 3 percent of DDT] proved far more promising in preliminary tests against these lice than any of the hundreds of synthetic organic compounds previously tested. Later tests confirmed the initial observations that DDT was a highly effective lousicide. DDT has no ovicidal properties. Two-piece, 50-percent-wool underwear impregnated with a solution of DDT when not washed remained effective for 3 to 5 weeks' wearing, while similar suits when washed once a week were effective for 2 to 3 weeks. Suits impregnated with a higher percentage of DDT when washed once a week remained completely effective through five washings and were still moderately effective after six washings. With a still larger percentage of DDT, garments gave complete control of lice after nine washings and 9 weeks' wearing. Impregnation has been accomplished by dipping the clothing in solutions of DDT in a volatile solvent or an aqueous emulsion, with no difference in effectiveness.--Bushland, McAlister, Eddy, and Jones (68).

Nontechnical references to lice affecting man

The effectiveness of DDT against lice on man has been mentioned by many other writers (15, 17, 18, 29, 33, 37, 38, 41, 42, 46, 58, 59, 62, 63, 70, 72, 75, 91, 118, 129, 137, 141, 153).

The use of DDT as the active ingredient of the Army's new louse powder has been widely heralded (4-8, 10, 11, 13, 14, 16, 17, 19-23, 25-30, 32, 36, 41, 43, 44, 45, 48, 49, 52, 56, 69, 113, 122, 150, 152). It has been credited with wiping out the typhus epidemic in Naples in the winter of 1943-44 (27, 34, 50, 55, 131).

The erroneous statement that the German army had a DDT louse powder before the Americans knew about it appears in certain articles (3, 35, 36, 39).

COLEOPTERA

Anobiidae

Lasioderma serricorne (F.), the cigarette beetle

Newly emerged beetles, confined in a modified Peet-Grady chamber, were sprayed with DDT in a light, volatile, highly refined oil of the kerosene type at the rate of 75 cc. per 1,000 cubic feet. The following results are recorded:

Insecticide in oil spray	Moribund after 24 hours	Mortality after 5 days
	<u>Percent</u>	<u>Percent</u>
DDT, 3 percent	28	44
DDT, 5 percent	50	66
Pyrethrum extract, 0.2 percent total pyrethrins	24	36
Unsprayed	2	19

The residual effect upon beetles placed in wire-gause cages that had been sprayed with 5 percent of DDT in oil is indicated as follows:

Interval between spraying of cage and exposure of insects	Time insects were exposed	Mortality	
		In sprayed cage	In unsprayed cage
<u>Days</u>	<u>Days</u>	<u>Percent</u>	<u>Percent</u>
0.2	2	100	24
9	3	96	0
37	3	92	8

Bostrichidae

Rhizopertha dominica (F.), the lesser grain borer

Of a large number of chemicals tested for impregnating paper bags, a 10-percent solution of DDT in acetone showed the greatest efficiency in preventing beetles from cutting through the bags. Paper impregnated with DDT and exposed for 2 months to the attack of this insect suffered no damage.--Cotton, Balzer, and Young (76).

Bruchidae

Bruchus pisorum (L.), the pea weevil

In laboratory tests adults were dusted with two strengths of DDT and then held 10 days in a cabinet at 86°F. Only 62 percent mortality was obtained with 0.3 gm. of 10-percent DDT, and only 11 percent mortality with 0.15 gm. of 2-percent DDT.--Schopp and Brindley (136).

Nontechnical reference

DDT proved ineffective (55).

Callosobruchus maculatus (F.), the cowpea weevil

In laboratory tests a 3-percent DDT dust mixed with Crowder peas (1-10,000) gave complete control of adults confined in the peas within 2 days. The derris standard (4.8 percent rotenone) gave similar results in the same period.--Swingle and Mayer (149).

Buprestidae

Agrilus sp., a fruit-tree borer

In a preliminary test in Switzerland a 1-percent Gesarol preparation [about 0.4 pound of DDT per 100 U. S. gallons] sprayed on fruit trees killed all the borers within 3 days.--Wiesmann (164).

Byturidae

Byturus tomentosus (Deg.), the raspberry beetle
Byturus urbanus (Lind.) (= B. fumatus)

Small-scale tests in Switzerland showed that the beetles perish within 24 hours of coming in contact with Gesarol spray deposits. In tests made out-of-doors one-half of the raspberry bushes in cultivation were sprayed with a 1-percent Gesarol mixture [about 0.4 pound of DDT per 100 U. S. gallons] shortly before the blossoms opened and a second time when they were fully open. On the untreated bushes the worminess was 17.1, 26.2, 34.7, and 42.5 percent, while on the treated bushes it was 0.5, 1.6, 2.3, and 3.0 percent. These results were considered very

satisfactory. Also additional tests were partly very good and partly satisfactory. There was not a single failure, and it can be stated that an effective control of raspberry beetles can be obtained with two applications of Gesarol, whereas three or four applications of derris are required to obtain satisfactory results.--Wiesmann (169).

In a preliminary test all the beetles treated with a mixture containing 1 percent of Gesarol were killed within 3 days.--Wiesmann (164).

Gesarol was effective against raspberry beetles.--Kotte (103).

Chrysomelidae

Cassida spp., tortoise beetles

In field tests in Switzerland Gesarol proved suitable for the control of these beetles on turnips.--Wiesmann (164).

Crioceris asparagi (L.), the asparagus beetle

Gesarol is used against this beetle.--Kotte (103).

Diabrotica balteata Lec., the banded cucumber beetle

In small-plot field tests an application of DDT-pyrophyllite dust (1-10) on cabbage at the rate of 18 pounds per acre killed 91 percent of adult beetles in 3 days.--Smith and Harrison (142).

Diabrotica duodecimpunctata (F.), the spotted cucumber beetle

Three days after the application of DDT-pyrophyllite dust (1-10) to cabbage plants at the rate of 18 pounds per acre, two spotted cucumber beetles were observed, one of which was nearly dead.--Smith and Harrison (142).

Epitrix cucumeris (Harr.), the potato flea beetle

In cage tests 10 adults were put on a potato-plant cutting that had been sprayed or dusted with DDT. Complete mortality was obtained in 24 hours with a 3-percent dust and in 72 hours with a spray containing 4 pounds of 5-percent DDT per 100 gallons of water.--Weigel (159)

Epitrix hirtipennis (Melsh.), the tobacco flea beetle

In cage tests complete mortality of 100 adults was obtained in 24 hours with a 5-percent DDT dust mixture. The insects were confined to small tobacco plants under four lantern globes, and the dust was applied by means of a precision duster.--Chamberlin (73).

Leptinotarsa decemlineata (Say), the Colorado potato beetle

A spray made of 1 pound of DDT concentrate per 100 gallons of water

caused complete mortality of all instars infesting potato plants in an outdoor garden.--Swingle and Mayer (149).

In greenhouse tests potato cuttings were sprayed or dusted with DDT. When the 3-percent dust was applied, all but one of the beetles were killed in 48 hours, and all were dead after 72 hours. With a spray containing 8 pounds of 5-percent DDT per 100 gallons, all the beetles were dead in 4 to 7 days. At 6 pounds per 100 gallons the spray was less effective. In a number of tests that followed in the greenhouse and in outdoor cages, results similar to those above were obtained on the adults, but the larvae were killed more easily.--Weigel (159).

In field tests in Switzerland Gesarol proved suitable for the control of this pest.--Wiesmann (163, 164).

Gesarol was effective.--Kotte (103).

Nontechnical references

DDT is highly effective against the Colorado potato beetle (20, 55, 72).

Gesarol is used against flea beetles (72, 103).

Coccinellidae

Epilachna varivestis Muls., the Mexican bean beetle

In laboratory tests DDT at 8 pounds to 100 gallons of water, with 0.8 pound of acacia as wetting agent, was sprayed on excised bean leaves, which when dried were put in unsprayed cages and infested with fourth instars. The mortality in 6 days was 45 percent. One pound of derris root (4.8 percent rotenone) in 100 gallons of water caused 67 percent mortality in the same time.--McGovran, Richardson, and Piquett (110).

When applied to growing plants in the greenhouse, neither the 3-percent dust nor a spray containing 8 pounds of the 5-percent DDT per 100 gallons caused any mortality of adults and larvae within 24 hours after application. The test insects were put on the plants after the insecticide was applied. None of the larvae died within 7 to 10 days. Coworkers who used DDT dusts and sprays against this insect on bush beans growing in their Victory gardens reported poor success.--Weigel (159).

In laboratory tests a 3-percent DDT pyrophyllite mixture killed only 36 percent of the third instars tested, while a derris mixture (0.5 percent rotenone) killed 70 percent within 3 days. In later tests 10-percent DDT killed fewer larvae than did the derris mixture. DDT had no appreciable repellent effect.--Harries (93).

A 10-percent DDT-pyrophyllite dust was tried in two field experiments. The results were very poor in comparison with the standard cube dust (0.5 percent rotenone).--Nelson (119).

Nontechnical reference

DDT is apparently not effective in controlling the Mexican bean beetle (55, 59).

Lady beetles (unidentified species)

Three days after the application of DDT-pyrophyllite dust (1-10) to cabbage plants at the rate of 18 pounds per acre, 1 dead lady beetle was observed.--Smith and Harrison (142).

Nontechnical reference

DDT kills the aphid's natural enemy, the ladybird beetle, with much more certainty than it does the aphid (55).

Curculionidae

Anthonomus grandis Boh., the boll weevil

In cage tests 2-percent DDT-pyrophyllite dust applied at the rate of 32 pounds per acre was comparatively ineffective, the mortality being only 18.5 percent.--Ivy (101).

In cage tests using 1- and 2-percent DDT-pyrophyllite mixtures, the mortality after 96 hours was 16 percent with each mixture, as compared with 77 percent when calcium arsenate was used. The weevils were released on the caged cotton plants, which were then thoroughly dusted with a hand gun.--Smith (146).

Nontechnical reference

The boll weevil is little affected by DDT (72).

Anthonomus pomorum (L.), the apple blossom weevil

Weevils collected out-of-doors in Switzerland were put in Petri dishes containing shoots of apple trees sprayed with Gesarol. The weevils that moved on the shoots showed symptoms of paralysis within 1 to 2 hours and died in 1 to 2 days. Small apple trees were sprayed with a mixture containing 1 percent of Gesarol and 1 percent of lime-sulfur, and 10 weevils were then put on each sprayed tree. After 8 days all the weevils were dead. This test indicated that an effective control may be obtained by spraying apple trees with a 1-percent concentration of Gesarol with or without lime-sulfur solution at the time of oviposition.--Wiesmann (169).

Gesarol was effective.--Kotte (103); Anon. (2).

Anthonomus rubi (Hbst.), the raspberry blossom weevil

In the raspberry cultivations sprayed with Gesarol in Switzerland only a few blossoms per thousand were destroyed by this weevil, while

in the untreated cultivations the damage amounted to 8 to 10 percent.--Wiesmann (169).

Gesarol was effective.--Kotte (103).

Listroderes obliquus Klug, the vegetable weevil

Three days after the application of DDT-pyrophyllite dust (1-10) to cabbage plants at the rate of 18 pounds per acre, 3 vegetable weevils were observed, 1 dead, 1 living, and 1 affected.--Smith and Harrison (142).

Pantomorus leucoloma (Boh.), the white-fringed beetle

In insectary and field-plot tests DDT was the most potent insecticide ever tested against the adults. In cage tests as a stomach poison a 2.5-percent DDT-pyrophyllite dust on cotton foliage killed 94 percent in 72 hours and on peanut foliage 100 percent in 48 hours. Comparative mortalities for the same periods with other poisons are 12 percent for synthetic cryolite on cotton, 53 for calcium arsenate on cotton, and 53 for cryolite on peanut. Sprays containing DDT (0.25 pound to 100 gallons of water) were equally good. DDT was also effective as a contact poison. It was very effective in field-plot tests.--Young (172).

Nontechnical references

DDT was highly effective against the white-fringed beetle (55, 59, 72).

Phyllobius oblongus (L.), the graft weevil

In Switzerland Petri dishes were sprayed with a 1-percent Gesarol mixture and allowed to dry for 24 hours. Weevils were put in these treated dishes for 5, 10, 15, and 30 minutes and then removed to untreated dishes for observation. All the weevils except those exposed for 5 minutes became paralyzed and later died.--Wiesmann (164).

Gesarol spray works well and rapidly.--Anon. (1).

Gesarol had a lasting lethal effect by contact.--Wiesmann (169).

Gesarol was effective in the laboratory and in the open.--Kotte (103).

Sitophilus oryza (L.), the rice weevil

In laboratory tests a 3-percent DDT dust mixed with wheat (1-10,000) caused 50 and 82 percent mortality of adults in 3 and 5 days, respectively. Derris (4.8 percent rotenone) at 1-200 killed 36 and 100 percent of the weevils in 4 and 7 days, respectively.--Swingle and Mayer (149).

Elateridae

Wireworms (unidentified species)

Gesapon [contains DDT and an emulsifying agent] produced appreciable results.--Kotte (103).

Meloidae

Epicauta lemniscata (F.), a blister beetle

In laboratory tests a 3-percent DDT dust on swiss chard leaves killed all adults within 3 days. Undiluted barium fluosilicate killed 96 percent under similar conditions. A 4-100 suspension of the 5-percent spray material on swiss chard killed 0, 71, and 96 percent in 2, 4, and 6 days, respectively. A 4-100 suspension of the undiluted cryolite killed only 25 and 75 percent in 4 and 6 days, respectively.--Swingle and Mayer (149).

Nitidulidae

Meligethes brassicae (Scoop.)

Gesarol may be effectively applied against this species on field crops.--Kotte (103).

Ostomidae

Tenebroides mauritanicus (L.), the cadelle

Same as for Rhizopertha dominica.--Cotton, Balzer, and Young (76).

Scarabaeidae

Melolontha vulgaris L., the May beetle

If the beetles are put in large containers provided with food sprayed with Gesarol, the insects eat very little and soon show symptoms of paralysis, and after 2 or 3 days die. Contact with the spray deposit for 1 to 3 hours causes moderate paralysis, and if removed from the poisoned food the beetles recover on the second day. If they are in contact with the spray deposit for 5 hours or more, severe paralysis results and death occurs on the fifth day. Three large branches of beech and oak trees were sprayed with a 1-percent Gesarol mixture in a greenhouse in Switzerland. Subsequently 300 beetles were released in the same compartment. Within a short time all untreated branches were densely covered with beetles. A number of beetles flew onto the treated branches but left them quickly. The test was repeated three times with the same result. The control food was always completely eaten, but the treated food was eaten little or not at all. Tests on a large scale showed that fruit trees may be protected against defoliation by a spray of Gesarol prior to the flying period of May beetles.--Wiesmann (169).

Gesarol when used at a concentration stronger than usual was effective.--Kotte (103).

Phyllopertha horticola (L.), the cockchafer

In a preliminary test in Switzerland all the beetles treated with a 1-percent Gesarol mixture were killed within 2 days.--Wiesmann (164).

Gesarol was effective as a deterrent.--Wiesmann (169).

Gesarol spray works well and rapidly.--Anon. (1).

Popillia japonica Newm., the Japanese beetle

DDT was the most effective of the protective materials tested. In laboratory tests sprays containing 0.25 pound of DDT per 100 gallons were consistently as effective as those containing 6 pounds of lead arsenate. In field tests one application protected fruit and foliage of early varieties of peach trees for about 10 days, which was the same protection as that given by two applications of the recommended derris-rosin residue emulsion. A single application of a spray containing 1 pound of DDT to 100 gallons protected the fruit and foliage during the period when the beetles were attacking the peach trees, and also destroyed the infestation on heavily infested plum trees and kept the trees free from beetles for the remainder of the season. This spray also protected grapes. DDT acted both as a poison and as a repellent and appeared very promising as a substitute for the derris, lime-aluminum sulfate, and lead arsenate sprays recommended for control of this insect. It remained effective longer than did derris and left no conspicuous residue on the fruit and foliage.--Fleming and Chisholm (78).

Nontechnical references

DDT is highly poisonous to the Japanese beetle (18, 29, 55, 56, 59, 63, 70, 72, 115, 154).

Rhizotrogus solstitialis (L.)

Gesarol was effective.--Kotte (103).

Scolytidae

Scolytus pruni, Ratz., the fruit-tree bark beetle

In Switzerland small apple twigs sprayed with a 1-percent Gesarol mixture were put in large Petri dishes, and when the twigs were dry 5 beetles were placed in each dish. After 2 to 3 hours the insects appeared paralyzed and within a day they died. In other tests beetles were placed in dishes that had been sprayed a month earlier. The insects showed severe symptoms of paralysis after 15 minutes and died within 24 hours.--Wiesmann (169).

Unidentified species

Gesarol at a heavier dosage than usual was effective against bark beetles on fruit trees.--Kotte (103).

Silphidae

Blitophaga sp.

Gesarol may be effectively applied against this insect on field crops.--Kotte (103).

Tenebrionidae

Tribolium castaneum (Hbst.), the red flour beetle

In laboratory tests a 3-percent DDT dust mixed with wheat at a dilution of 1 to 10,000 parts by weight caused 100 percent mortality of adults confined in the treated grain for 2 days.--Swingle and Mayer (149).

LEPIDOPTERA

Bombycidae

Bombyx mori (L.), the silkworm

In laboratory tests against silk moth larvae on mulberry leaves, DDT, when applied as a 10-percent dust, was at least as toxic as lead arsenate.--Martin (115).

Crambidae

Diatraea saccharalis (F.), the sugarcane borer

Small plots of sugarcane were dusted four times with DDT-pyrophyllite (50-50) at the rate of 8 pounds per acre per application. This mixture gave a lower degree of borer control than did synthetic cryolite, although not significantly so.--Ingram (100).

Geometridae

Alsophila pometaria (Harr.), the fall cankerworm

The following field tests were made: (1) Seven trees were banded with burlap that had been saturated with 5-percent DDT emulsion; (2) the trunks of four trees from the base up to about 4 feet above the ground were sprayed with a similar emulsion; (3) the trunks of five trees were dusted for the same distance with a 50-50 DDT-pyrophyllite mixture. DDT-pyrophyllite dust killed all female moths that came in contact with it. The moths did not die immediately but quickly lost all power of locomotion. DDT emulsion was not very effective in the field, but moths confined in cloth-covered cages the inside of which

had been sprayed with the emulsion soon lost all power of locomotion and died within 24 to 48 hours.--Schaffner (133).

Cheimatobia brumata (L.), the winter moth

Gesarol was effective.--Kotte (103).

Hibernia aurantiaria (Esp.)

Gesarol spray works well and rapidly.--Anon. (1).

Hibernia sp.

In a preliminary test in Switzerland a 1-percent Gesarol spray on fruit trees killed all these insects within 2 days.--Wiesmann (164).

Hesperiidae

Urbanus proteus (L.), the bean leaf roller

In laboratory tests a 3-percent DDT-pyrophyllite dust on bean foliage killed 100 percent of third instars within 2 days, with almost no feeding. The pyrethrum standards (1.2 percent pyrethrins) killed 96 percent in the same period. A spray containing 4 pounds of DDT per 100 gallons of water gave excellent control of the first three instars in an outdoor garden.--Swingle and Mayer (149).

Hyponomeutidae

Acrolepia assectella (Zell.)

Gesarol is used against this insect on truck crops.--Kotte (103).

Hyponomeuta malinellus Zell., the ermine moth

Several branches on apple trees in Switzerland were sprayed with a mixture containing 1 percent of Gesarol and 2 percent of lime-sulfur. After 2 days the caterpillars on the sprayed branches were dead, and the result was at least equally as good as that obtained with the arsenical compound formerly used.--Wiesmann (164).

The southern sides of six plum trees in Switzerland were sprayed with a mixture containing 1 percent of Gesarol and 1 percent of lime-sulfur, while the northern sides were left unsprayed as controls. Later there were nine nests of caterpillars on the control sides and none on the sprayed sides.--Wiesmann (169).

Gesarol was effective.--Kotte (103).

Plutella maculipennis (Curt.), the diamondback moth

In small-plot field tests with two applications of DDT-pyrophyllite

(1-10) on cabbage at the rate of 14 pounds per acre, 1 caterpillar survived per 100 plants, while 10 survived applications of pyrethrum (0.3 percent pyrethrins) dust, and 4 of derris (0.5 percent rotenone) dust.--Smith and Harrison (142).

Gesarol is used against this species on truck crops.--Kotte (103).

Olethreutidae

Carpocapsa pomonella (L.), the codling moth

In preliminary laboratory spray tests DDT (1 pound to 100 gallons of water) appeared significantly more effective than lead arsenate (3 pounds to 100 gallons), giving nearly perfect control. In laboratory-field tests DDT at the same strength was highly effective, even after long periods of weathering. Other tests suggested that DDT could probably be used effectively after first-brood sprays of either nicotine bentonite with soybean oil or lead arsenate and lime with mineral oil. In field tests not only did the DDT at 1.5 pounds prevent worm entrances, but there were no new stings at harvest and less than 3 percent of the picked apples were wormy. DDT did not repel ovipositing moths.--Steiner, Arnold, and Summerland (147).

When tested by the apple-plug method, DDT showed excellent promise when used alone at concentrations of 1 or more pounds per 100 gallons. It showed little to no loss in effectiveness when combined with bordeaux mixture, neutral soap, or pyrophyllite, but the addition of hydrated lime, bentonite, and lime-sulfur reduced its toxicity somewhat. One pound of DDT per 100 gallons of water gave 16 percent of wormy and 12 percent of stung apple plugs, whereas lead arsenate (4 pounds to 100 gallons) gave 44 percent of wormy and 5 percent of stung plugs.--Siegler (139).

Gesarol, applied as a 1-percent spray mixture, acted both as a stomach and a contact insecticide on codling moth larvae. It was miscible with all kinds of fungicides and after being sprayed produced an adhesive, whitish deposit, which resisted the rain fairly well and remained visible up to 3 weeks.--Wiesmann (164).

In tests on a small scale Gesarol was first found inferior to lead arsenate, but later tests showed it to be effective. Apples sprayed with Gesarol were suspended in cages, where female moths laid eggs on them. Only 2.3 percent of the larvae resulting from 128 eggs deposited on 26 sprayed apples were able to eat their way into the apples, whereas the infestation of the check apples was 97.5 percent. Tests were conducted in orchards in three localities in Switzerland. In Wädenswil lead arsenate generally effected a greater reduction of infestation, but Gesarol was equally effective in some cases. The spray mixture contained 1 percent of Gesarol or 1 percent of lead arsenate plus 1 percent of lime-sulfur solution (32° Bé.). The Gesarol-lime-sulfur mixture formed a suspension which had to be constantly stirred, the resistance to rain of its white deposit on the fruits was not entirely satisfactory, and its wetting and spreading properties were also poor. In

Herrenhof this mixture was equally effective as 0.5 percent of lead arsenate plus lime-sulfur. In the third locality, Oeschberg, tests were carried out in three towns comparing 1 percent of Gesarol with 0.5 percent of lead arsenate, each mixed with 1 percent of lime-sulfur. At Lindenhof and St. Niklaus Gesarol was unsatisfactory on one variety of apple after two treatments, but on a second variety it was half as effective as the lead arsenate. The results obtained at Utzenstorf were conclusive.--Wiesmann (169).

Gesarol sprays were inferior to those of lead arsenate in tests made in 1941.--Anon. (1).

Nontechnical references

DDT has been found to be very poisonous to the codling moth (16, 20, 22, 55, 59, 72, 113, 118, 150, 154).

Grapholitha funebrana (Treit.), the plum tortricid moth

Four prune trees in a large orchard in Switzerland were sprayed with 1 percent of Gesarol in water, on June 17, 1942, and the records were taken at harvesttime, September 3. The spray deposit on the leaves was good and fairly compact, but on the fruits spotlike and not uniform. The single application reduced the infestation about 30 to 40 percent, which corresponded somewhat to the reduction obtained by two applications of nicotine sprays. As Gesarol showed a lasting effect, which nicotine preparations lacked, the spraying with Gesarol might be used during the first third of July and thus coincide with the second codling moth treatment.--Wiesmann (169).

Grapholitha molesta (Busck), the oriental fruit moth

DDT (1 pound to 100 gallons of water) caused a marked reduction in moth injury to peaches after one spraying, and the treatment apparently was effective for 3 to 4 weeks.--Driggers (77).

In the laboratory DDT in all the forms tested was highly toxic to the newly hatched larvae. DDT was very effective when dissolved in oil and other organic solvents or when prepared in dust mixtures. Deposits on fruit prevented the entry of large numbers of these larvae. DDT was also highly toxic to the moths when they were confined in cages with sprayed peach foliage or the sides of the cages were sprayed or dusted.--Carman and Fleschner (71).

DDT was effective in laboratory tests.--Boyce (67).

Nontechnical references

DDT is effective against the oriental fruit moth (55, 115).

Grapholitha sp.

Gesarol was effective.--Kotte (103).

Spilonota ocellana (D. & S.), eye-spotted budmoth

In a preliminary test in Switzerland a 1-percent Gesarol preparation sprayed on fruit trees killed all the budmoths within 3 days.--Wiesmann (164).

Phalaenidae

Agrotinae

Five days after the second application of DDT-pyrophyllite dust (1-10) at the rate of 14 pounds per acre, all these caterpillars on cabbage plants were killed.--Smith and Harrison (142).

Alabama argillacea (Hbn.), the cotton leafworm

Two-percent DDT-pyrophyllite dust applied in cage tests at the rate of 32 pounds per acre of cotton gave only 35.5 percent net mortality.--Ivy (101).

In a field test using 2-percent DDT-pyrophyllite dust at rates of 5 and 10 pounds per acre, no mortality was observed after 6 days.--Clark (74).

Anticarsia gemmatilis (Hbn.), the velvetbean caterpillar

In a laboratory cage test of a 2.5-percent DDT-pyrophyllite dust and a cryolite-wheat flour dust (9-1) against half-grown caterpillars on peanut foliage, 48 hours were required for DDT and 96 hours for cryolite to cause 100 percent mortality. A field plot of velvetbeans was sprayed twice with 0.5 pound of DDT plus 3 pints of raw linseed oil per 100 gallons of water. The first application was made at the rate of 58 gallons per acre and gave good control. The second application protected the new foliage from the hordes of caterpillars that were moving in from the surrounding untreated area.--Young (172).

Barathra brassicae (L.)

Gesarol is used against this species on truck crops.--Kotte (103).

Heliothis armigera (Hbn.), bollworm, corn earworm, tomato fruitworm

A water suspension of 2-percent DDT-pyrophyllite killed bollworms when put on the dorsum with a pipette. The median lethal dose of DDT applied in this manner to 240 fifth instars was 0.299 mg. per gram of body weight. This mixture, applied as a dust at 32 pounds per acre of cotton in cage tests, killed 96 percent of third instars, whereas basic copper arsenate-sulfur (1-1) at 16 pounds per acre killed 86 percent. In another series of cage tests DDT caused 97 percent mortality at 32 pounds, 82 percent at 16 pounds, and 63 percent at 8 pounds per acre. Calcium arsenate at 8 pounds per acre killed 62 percent. DDT acts both as a stomach poison and as a contact insecticide, the latter being the

more important. Bollworms were readily killed by exposure to dust clouds of this material. Following a 30-second exposure 40 percent kill was obtained with fifth instars, 90 percent with fourth instars, and 100 percent with third instars. Larvae were also killed when put on sheets of blotting paper and dusted at the rate of 32 pounds per acre. Larvae fed on dusted leaf sandwich consumed a lethal dose after 2 to 4 days' exposure.--Ivy (101).

Screen cages were placed over cotton plants on which bollworms had been released, and the plants were then dusted with 2-percent DDT-pyrophyllite dust. The mortality was 100 percent in 46 hours in one test, but poor in another.--Stevenson, Sheets, and Breazeale (148).

In small field plots tomato plants dusted with 3 and 1 percent of DDT in pyrophyllite and with undiluted calcium arsenate produced, respectively, 4, 8, and 6.5 percent of worm-injured tomatoes, as compared with 28.5 percent on untreated check plants. The results showed good promise for DDT in the control of the tomato fruitworm. In laboratory tests complete mortality was obtained of 30 larvae fed leaves dusted with the 3 percent of DDT. Of 30 others fed leaves dusted with the 5-percent mixture 29 died. In comparable tests with calcium arsenate 25 larvae died. The respective deposits were 69, 42, and 15 micrograms per square centimeter. More feeding took place on the calcium arsenate than on the DDT.--Johnson (102).

DDT has been tested against the bollworm. (20).

A dust of DDT-pyrophyllite (1-10) applied at the rate of 18 pounds per acre caused a tomato fruitworm to regurgitate and quiver 2 hours after the treatment.--Smith and Harrison (142).

Prodenia eridania (Cram.), the southern armyworm

In laboratory tests a 3-percent DDT-pyrophyllite dust on collard leaves killed 100 percent of fourth instars within 2 days. Pyrethrum (1.2 percent pyrethrins) killed only 48 percent in the same time. An 8-100 suspension of the 5 percent DDT, applied as a spray to collard plants, caused 100 percent mortality within 2 days. This foliage was equally toxic to larvae 8 days after application of the spray. Undiluted lead arsenate at 8-100 killed 97 percent in 2 days.--Swingle and Mayer (149).

Pseudoplusia (= Autographa) rotationis (Guen.), a looper

In laboratory tests DDT dust dilutions as low as 1 percent killed 90 to 100 percent of fourth instars within 2 days, and 0.6-percent DDT dust killed 100 percent in 3 days. A derris dust (0.96 percent rotenone) killed 89 percent in 3 days. A 8-100 suspension of the 5-percent DDT applied to collard plants killed 33, 85, and 96 percent of fourth instars in 2, 4, and 6 days, respectively. A 4-100 spray killed only 62 percent in 6 days. Lead arsenate at 8-100 caused 100 percent mortality within 4 days, and derris (4.8 percent rotenone) at 4-100 killed 46 percent in 6 days.--Swingle and Mayer (149).

Trichoplusia ni (Hbn.) (= Autographa brassicae (Riley)), the cabbage looper

In laboratory tests a 3-percent DDT-pyrophyllite dust on collard leaves killed 100 percent of fourth instars within 2 days. The pyrethrum standard (1.2 percent pyrethrins) killed 96 percent in the same time.--Swingle and Mayer (149).

In small-plot field tests with two applications of DDT-pyrophyllite dust (1-10) on cabbage at the rate of 14 pounds per acre, 5 loopers survived per 100 plants, as compared with 51 on plants treated with pyrethrum (0.3 percent pyrethrins) and 70 on plants treated with derris-pyrophyllite (0.5 percent rotenone).--Smith and Harrison (142).

Phaloniidae

Phalonia ambiguella (Hbn.), a European vine moth

In Switzerland Gesarol applied as a spray at a concentration of 1 percent [8 pounds per 100 U. S. gallons] proved effective against the second-generation larvae.--Wiesmann (162, 163).

Phycitidae

Ephestia elutella (Hbn.), the tobacco moth

Newly emerged adults, confined in a modified Peet-Grady chamber, were sprayed with DDT dissolved in a light, volatile, highly refined oil of the kerosene type at the rate of 75 cc. per 1,000 cubic feet. Results were as follows:

Insecticide in oil spray	Moribund after 24 hours	Mortality after 3 days	Eggs deposited in 3 days
	Percent	Percent	Number
DDT, 3 percent	90	94	1298
DDT, 5 percent	98	100	1039
Pyrethrum extract, 0.2 percent total pyrethrins	95	96	1202
None, unsprayed	4	16	380

Moths confined for 3 days in wire-gauze cages that had been sprayed with 5 percent of DDT in oil and allowed to air for 2 days were all killed, and after 15 days' exposure (introduced 14 days after spraying) 20 percent of the larvae were dead.--Tenhet (151).

Pieridae

Pieris brassicae (L.), the cabbage white butterfly

Gesarol is used against this species on truck crops.--Kotte (103).

Pieris rapae (L.), the imported cabbage worm

In laboratory tests a 5-percent DDT dust on collard leaves killed all fourth instars within 2 days. The derris standard (4.8 percent rotenone) gave the same results.--Swingle and Mayer (149).

In small-plot field tests with two applications of DDT-pyrophyllite (1-10) on cabbage at the rate of 14 pounds per acre all larvae were killed. The same was true for pyrethrum (0.3 percent pyrethrins) and derris (0.5 percent rotenone) dusts.--Smith and Harrison (142).

Larvae one-third to nearly grown confined on cabbage plants in insectary cages were dusted with 10 percent DDT-pyrophyllite and with derris (0.75 percent rotenone). In 3 days the respective mortalities were 90 and 100 percent.--Harrison (94).

Pyraustidae

Diaphania hyalinata (L.), the melon worm

Diaphania nitidalis (Stoll), the pickleworm

In laboratory tests all dilutions of DDT dusts down to 0.6 percent caused 90 to 100 percent mortality of fourth instars of melon worms on pumpkin foliage, and 100 percent of pickleworms. Derris dust (0.96 percent rotenone) killed only 36 percent of melon worms and 24 percent of pickleworms in 2 days. An 8-100 DDT spray caused 100 percent mortality of the pickleworm in 2 days and a 4-100 spray in 4 days. The respective mortalities of the melon worm with an 8-100 spray were 55 and 100 percent. Derris (4.8 percent rotenone) at 4 pounds per 100 gallons killed 100 percent of pickleworms in 4 days, but only 77 percent of melon worms in 6 days at 8-100.--Swingle and Mayer (149).

Evergestis rimosalis (Guen.), the cross-striped cabbage worm

In laboratory tests a 3-percent DDT dust applied to collard leaves killed all fourth instars within 2 days. The pyrethrum (1.2 percent pyrethrins) standard gave similar results. At 4 pounds per 100 gallons the 5-percent spray killed 90 and 100 percent of third instars in 2 and 4 days, respectively. Derris (4.8 percent rotenone) at 8 pounds per 100 gallons killed 3 and 100 percent in 2 and 4 days.--Swingle and Mayer (149).

Larvae, one-third to nearly grown, confined on cabbage plants in cages in an insectary were dusted with 10-percent DDT-pyrophyllite. In 3 days the mortality was 100 percent, while for derris (0.75 percent rotenone) the mortality was only 80 percent.--Harrison (94).

Pyrausta nubilalis (Hbn.), the European corn borer

In laboratory and field tests DDT was the only one of many materials tested that held promise of becoming a satisfactory substitute for ground derris or cube, because of its relatively high reduction of borers in both corn ears and plants without injury to the corn. A proprietary product containing 5 percent of DDT applied as a spray at the rate of 4 pounds per 100 gallons killed all the borers.--Questel (128).

In small plots at Toledo, Ohio, a powder containing 5 percent of DDT used as a spray at the rate of 6 pounds per 100 gallons reduced the borers in the plants 91.9 percent and in the ears 96.1 percent.--Questel (127).

Sphingidae

Protoparce sexta (Johan.), the tobacco hornworm

Second and third instars on tobacco plants in cages were dusted. Complete mortality of 70 larvae was obtained in 48 hours with a 3-percent DDT dust applied at the rate of 15 to 20 pounds per acre, and all of 50 larvae treated with lead arsenate were dead in 48 hours. The larvae consumed very little of the foliage dusted with DDT.--Chamberlin (73).

Tineidae

Clothes moths (unidentified species)

A milky emulsion suitable for use as a spray for the destruction of moths is made by dissolving 15 parts of DDT in a warm mixture of 30 parts of toluene and 15 parts of methyl hexaline [methyl cyclohexanol], adding 36 parts of sulfonated castor oil and 4 parts of ammonia, stirring well for some time, and diluting the resulting clear solution with 50 to 100 times its quantity of water.--Geigy (80).

Pumice stone, charcoal, kieselguhr, or other natural or artificial porous mass is steeped with a solution of 10 parts of DDT in 20 parts of benzene and dried under reduced pressure. The product is suitable for use as a moth-repelling and a moth-destroying agent.--Geigy (81).

Moths are destroyed within a very short time by a spray of DDT in alcohol, petroleum, or similar solvent or in an aqueous emulsion. DDT can be used for the preparation of solid mothproofing agents, such as moth balls, and in combination with compounds already employed for the same purpose.--Miller (117).

Nontechnical references

DDT was originally developed in Switzerland as a moth repellent for clothing (11, 15, 20, 21, 44, 72) and its effectiveness as a mothproofing agent has been reported in the United States (55, 154).

Tortricidae

Archips fumiferana (Clem.), spruce budworm

"I think there are possibilities with the use of DDT for budworm."--Annand (59).

Unidentified species

Gesarol spray works well and rapidly against budworms and webworms.--Anon. (1).

HYMENOPTERA

Apidae

Apis mellifera L., the honeybee

In Switzerland 10 bees taken from the combs at the back of the hive were placed in small closed cages and fed a spray mixture containing 10 percent of sugar, 2 percent of honey, and 1 percent of Gesarol on pads of cotton. The bees would not eat the usual spray mixture containing 1 percent of Gesarol, but they readily accepted this sweetened mixture. These trials were repeated three times, and in order to keep the bees as lively as possible the cages were kept at 28°C. Not one of the bees fed Gesarol or the control bees died within 10 days, but all the bees fed a 0.5-percent lead arsenate solution were dead within 3 days and all fed 1-percent lead arsenate died within 2 days.--Wiesmann (163, 164).

In order to test the effect of Gesarol spray deposits as a contact poison on bees, an old comb was thoroughly sprayed with a 1-percent mixture. When the spray had dried, the comb was put in a one-frame observation hive and 50 bees were introduced. Within 6 days 4 bees in this hive died while 5 died in the control hive. Therefore, the dried Gesarol deposits did not harm the bees that crossed the treated comb hundreds of times. These results indicate that the spray deposits on fruit trees would not be injurious to bees. To determine whether a direct wetting of the bees with a spray of Gesarol would poison them, 20 bees were sprayed with a 1-percent mixture. The insects were completely paralyzed in 1 hour and dead in 4 hours. To test the effect of Gesarol dust, a comb was dusted and then put in the one-frame observation hive. Within 4 hours all 50 bees were dead.--Wiesmann (164).

The bee experiment in rearing frames proves unequivocally that dried residues of Gesarol sprays are unobjectionable to bees coming in contact with them. Therefore, a preblossom spraying of fruit trees with Gesarol is harmless to the bees visiting the blossoms. Bees are killed by direct wetting with a Gesarol spray.--Wiesmann (165).

Three days after the application of DDT-pyrophyllite dust (1-10) to cabbage plants at the rate of 18 pounds per acre, 1 dead honeybee was observed.--Smith and Harrison (142).

DDT (0.05 percent) in dilute honey and in queen-cage candy was fed to caged honeybees, at least 20 young bees per cage. In 6 such trials the majority of the bees were dead within 17 to 42 hours, whereas few or no bees in the 6 control cages were dead. Both drones and worker bees were affected. Several hours after taking candy or sirup containing DDT the bees became agitated, and later died. No contact-poisoning effect was demonstrated when bees were kept in cages previously sprayed with 0.05 percent DDT or when the bees were sprayed directly. However, when 1 or 2 percent DDT spray was used, within 6 hours most of the bees were dead and the rest were poisoned. Therefore, DDT is a stomach poison for honeybees at 0.05 percent concentration, and at 1 percent it also acts as a contact poison.--Holst (97).

Nontechnical references

DDT kills bees as readily as it does other insects (55). The Swiss work with Gesarol against bees is mentioned (22).

Formicidae

Formica sp., an ant

DDT applied in relatively low concentrations in an artificial chamber was toxic to ants. They had considerable difficulty in walking within a few minutes after coming in contact with the residue of the 5 percent DDT-acetone solution and died several hours later. The 5 percent mixture, when applied as a dust, acted a little more slowly, and the 1 percent solution in acetone still more slowly, but both were effective.--St. George (132).

Iridomyrmex humilis Mayr, the Argentine ant

A thin line of DDT was placed across an ant trail in a greenhouse, but the ants did not detour to avoid crossing it. They apparently suffered no ill effects from contact with it. Several puffs of undiluted DDT dust were blown into a nest of ants. For 9 days thereafter no ants were observed; therefore, they either abandoned the nest or all were killed.--Ingram (100).

Nontechnical reference

DDT appears to be effective against ants (72).

Tenthredinidae

Hoplocampa flava (L.), the plum fruit sawfly
Hoplocampa minuta (Christ.), continental plum sawfly

The southern sides of six plum trees in Switzerland were sprayed with a mixture containing 1 percent each of Gesarol and lime-sulfur, while the northern sides of these trees were left unsprayed as controls. The infestation was reduced in the worst case to one-third and in the best case to one-tenth; the first was considered acceptable and the second, good.--Wiesmann (169).

Hoplocampa testudinea (Klug), apple sawfly
Pteronidea ribesii (Scop.), imported currant worm, gooseberry sawfly

Gesarol was effective against these species.--Kotte (103).

DIPTERA

Anthomyiidae

Hylemya antiqua (Meig.), onion maggot
Hylemya brassicae (Bouché), cabbage maggot

Gesapon [DDT and an emulsifying agent] has produced appreciable results against these larvae.--Kotte (103).

Culicidae

Mosquitoes. Nontechnical references

DDT offers wide potential use in mosquito control (7, 15, 18, 20, 32, 37, 45, 56, 114, 123, 125, 150), and particularly as a larvicide (11, 89, 115, 122, 137).

Itonididae

Contarinia torquens Meij.

Gesarol is used against this fly on truck crops.--Kotte (103).

Muscidae

Musca domestica L., the housefly

DDT "reacts surely against flies by spraying 5 cc. of an alcoholic solution of 5 percent strength per cubic meter of room." The flies are killed within 2 hours, and after 10-15 minutes nearly all flies are so paralyzed that they can no longer fly.--Muller (117).

In Switzerland houseflies were confined for various periods in Petri dishes that had been sprayed with a 1-percent preparation of Gesarol and allowed to dry. Contact with the dry spray deposits for only 30 seconds within 35 hours of the treatment was fatal to the flies. A 60-minute contact caused paralysis in 10 minutes and killed them within 3 to 4 hours. The longer the exposure the sooner severe convulsions took place, followed by a quicker death. The dried Gesarol deposits upon the glass

retained their potency for at least 3 months. Since flies have sense organs in their tarsi, these organs were probably first affected, then paralysis of the legs resulted, followed by rapid injury to the nervous system, and finally death.--Wiesmann (167, 168, 170).

When sprayed on surfaces in suitable solvents, DDT remains as a nearly invisible deposit after the liquid has volatilized, and acts as a contact insecticide. When applied in unpainted wooden cages at the rate of 25 mg. of DDT per square foot, DDT in dibutyl phthalate was less effective than in ethylene dichloride or kerosene. Of all the solvents tested, kerosene appeared to be the most desirable for the immediate use of the armed services. In cages sprayed with 5 percent of DDT in kerosene the time required for complete knock-down ranged from 15 minutes for flies introduced after 15 days to 300 minutes for flies exposed after 93 days. These cages were still effective on the 265th day after spraying. There were differences in knock-down by DDT on different surfaces and at different temperatures. Flies have been knocked down and killed by dosages as low as 0.25 mg. per square foot. The walls and ceilings of the milk barn and feed room of several dairies were sprayed once with 5 percent DDT in kerosene. The immediate reduction of flies was approximately 95 percent, and for several months the population continued to be much lower than in untreated barns.--Lindquist, Madden, Wilson, and Jones (107).

Experiments were conducted to ascertain how long DDT can be depended on to prevent an accumulation of houseflies. Small cages sprayed inside with 2 percent of DDT in kerosene or a 1 percent suspension in water killed all the flies put into them for nearly 5 months. Large cages sprayed inside with a 1 percent suspension of DDT in water knocked down all the flies put into them in 60 to 120 minutes over a period of 4 months, and none recovered. A small dairy barn was treated inside with 1 percent each of DDT and pyrophyllite and 0.5 percent of sodium lauryl sulfate in water. Flies were released in this room a week later and at irregular intervals for 3 months. The first releases required 75 minutes for complete knock-down, whereas the last release required 120 minutes. All the flies succumbed. The residue on the walls retained its toxicity for 103 days. A large dairy barn, heavily infested with flies, was sprayed with the 1 percent aqueous suspension of DDT and 38 observations were made from June 29 to October 8. The maximum number of flies at any one time was 56, the minimum 0, and the average for the entire period was 10.8. In 9 other barns treated with DDT the infestations were completely destroyed and no considerable numbers of flies accumulated after the treatments.--Van Leeuwen (157).

Effective control of housefly breeding can be obtained in manure, when it is thoroughly treated (0.6 gallon per cubic foot) with DDT-water emulsions in concentration as low as 0.1 percent.--Simmons and Wright (140).

In laboratory tests by the spray-tunnel method a spray containing 0.25 gm. of rotenone per liter of deodorized kerosene left the same percentage of flies active at the end of 6 hours as a spray containing 1

gm. of DDT, and 1 gm. of rotenone was about as effective as 2.5 gm. of DDT. Therefore, rotenone is 2.5 to 4 times as effective as DDT against flies when applied by this method. The rotenone was in the form of an extract containing 5.04 gm. of rotenone per 100 ml. plus other extrac-tives.--Hunt (99).

Tests by the turntable method showed that DDT at concentrations above 0.2 percent (w./v.) in deodorized kerosene caused a pronounced knock-down of houseflies in 10 minutes but at lower concentrations the knock-down was negligible. The toxicity of DDT increased much more rapidly with increase in concentration than did that of the pyrethrins. Consequently, below 0.7 mg. per milliliter, at which concentration the two materials had the same toxicity to these houseflies, the pyrethrins were more toxic, and above this concentration DDT was more toxic. When the results were plotted on log-probability paper, it was found that the concentration required to give 50 percent mortality was 1.65 mg. per milliliter for pyrethrins and 0.95 mg. for DDT. In tests by the Peet-Grady method when 12 ml. were used per test, 0.2 percent of DDT in deodorized kerosene, combined with 0.03 percent of pyrethrins, 1 per-cent of fenchyl thiocyanacetate, or 1.5 percent of commercial beta-butoxy-beta'-thiocyanodiethyl ether, knocked down and killed all the flies. DDT alone in deodorized kerosene caused less than 50 percent knock-down in 10 minutes when 0.5 percent or less was used; at 1 and 2 percent of DDT much higher knock-down was obtained, but even at 2 per-cent all the insects were not knocked down in 10 minutes.--Gersdorff and McGovran (87).

Samples of housefly breeding media (23 gm. each) were treated with DDT and infested with third-instar houseflies. The cultures were then held until the adults emerged. In samples treated with 60 and 30 mg. of DDT 88 and 77 percent of the larvae died, as compared with 92 percent when 60 mg. of borax was added to similar culture. Thiourea is much more toxic, for only 7.5 mg. added to each 23 gm. of media caused 92 percent mortality.--McGovran, Richardson, and Piquett (110).

Nontechnical references

DDT is highly effective against flies (7, 15, 20, 26, 46, 75, 89, 115, 118, 123, 150, 152, 154), and surfaces sprayed with it remain toxic for several months (16, 17, 18, 20, 29, 32, 33, 40, 41, 55, 56, 59, 63, 70, 72, 121, 129, 141, 155).

Siphona irritans (L.), the horn fly

Tests were conducted with DDT in aerosols and emulsions for the control of horn flies on beef cattle under ranch conditions. Tests with aerosols containing 5 percent of DDT, 10 percent of sesame oil (or acetophenone), 20 percent of Freon 113 (trichlorotrifluoroethane), and 65 percent of methyl chloride indicate that satisfactory control may be obtained for 2 weeks by a single spraying. Equally satisfactory control was obtained when DDT in emulsions was applied to range cattle with a power sprayer at 300 pounds' pressure. In one operation 90

cattle were sprayed all over with one nozzle in 1 hour. The best emulsion formula contained DDT 100 gm., benzene 140 ml., dibutyl phthalate 140 ml., and Triton NE 12 gm. Water was added to make 1 liter. The emulsions were found to stand indefinitely and to mix readily with water.--Wells (160).

Nontechnical references

DDT is highly effective for killing horn flies (59, 72, 154).

Stomoxys calcitrans (L.), the stablefly, the dog fly

Tests were made in Switzerland in which stableflies were confined in Petri dishes that had been sprayed with Gesarol. Contact with the dry spray deposit for 60 minutes was fatal to them within 4 hours and a 30-minute contact was fatal in 35 hours. A small horse stable and a cow barn with 10 cows and 2 heifers were sprayed with a 1 percent Gesarol [about 0.4 pound DDT per 100 U. S. gallons] preparation at the rate of 1 liter per square meter of surface. The flies dropped at once from the ceiling and landed in a paralyzed state on the floor, where they soon succumbed. The cow barn soon became free from flies and remained practically free for 36 days. It was concluded that spraying the stables early in June and again at the beginning of August will eliminate flies for the whole summer.--Wiesmann (166, 167, 168).

Three applications, 10 to 12 days apart, were made to each of two screened horse barns with DDT in white kerosene (2 gm. to 100 ml.). The spray was applied as a mist with a small knapsack sprayer. Approximately 8 gallons of material was applied to 2,000 square feet of wall surface, which was enough to wet it without run-off. Previous to this treatment the 44 horses were held inside during bad fly outbreaks and a commercial fly spray was used. After the DDT applications no further sprays were necessary to protect the horses, although the spraying did not apparently reduce the number of flies outside the barns. In another barn a single window screen was sprayed with DDT in kerosene (5 gm. per 100 ml.). At the end of 13 days this window was still killing flies. At another barn 100 percent kill was obtained for 12 days in eight unoccupied stalls sprayed with 2 gm. of DDT per 100 ml. of kerosene. Sprays containing DDT in various solvents applied to horses in 4-ounce doses, twice daily for as many as 35 applications, gave a 100 percent knock-down and kill of flies alighting on the animals. No repellent effect was obtained with DDT. The most efficient repellent combination used was DDT in Indalone at 2 gm. per 100 ml. When used as a spray on horses this solution gave 100 percent kill, 1 hour of complete protection, from 2 to 4 hours of satisfactory partial protection, and a residual deposit on the animal that remained toxic for a few days.--Blakeslee (65).

Effective control of the stablefly breeding in peanut litter was obtained when it was thoroughly treated with a DDT-water emulsion in concentrations as low as 0.25 percent of DDT. The emulsion was made by diluting a stock formula containing 10 gm. of DDT, 12.5 ml. of

benzene, 2.5 ml. of B-1956 emulsifier, and 75 ml. of water.--Simmons and Wright (140).

DDT, especially if a wetting agent is added to the spray, is very effective in the control of flies in stables.--Kotte (103).

Otitidae

Otites fulminans (Meig.)

Psilidae

Psila rosae (F.), the carrot rust fly

Gesapon [contains DDT and an emulsifying agent] has shown appreciable results against the larvae of these two species.--Kotte (103).

Syrphidae

Unidentified species

Three days after the application of DDT-pyrophyllite dust (1-10) to cabbage plants at the rate of 18 pounds per acre, 1 live syrphid fly larva was observed which was active and apparently unaffected.--Smith and Harrison (142).

Trypetidae

Anastrepha ludens (Loew), the Mexican fruitfly

DDT at concentrations of 0.5, 1, 2, 4, and 8 pounds per 100 gallons was tested against adult flies confined in cages. These solutions were made by dissolving the DDT in 20 ml. of acetone and diluting to 200 ml. by the addition of a solution containing 20 pounds of sugar and 1 pound of dried Chinese egg albumen in 100 gallons of water. The toxicity was very erratic. All the flies died upon exposure to 2 and 4 pounds, but some of the flies survived when exposed to the other concentrations. Two pounds of tartar emetic was considerably more toxic than any of these concentrations of DDT tested.--Plummer (126).

Rhagoletis cerasi (L.), the European cherry fruitfly

The tops and bottoms of Petri dishes were sprayed with 1 percent Gesarol and allowed to dry, and then flies were put in the dishes. No effect was observed within 2 hours, but the flies were completely paralyzed after 6 hours and dead within 9 to 20 hours. Branches of cherry trees in cages were sprayed with 1 percent Gesarol and allowed to dry. After several days flies were introduced, and within several hours they were paralyzed, fell to the bottom, and usually were inactive after 24 hours. In field experiments the spraying of six cherry trees with 1 percent Gesarol proved to be ineffective, but when a secluded group of

trees was thoroughly sprayed with 1 percent Gesarol by use of a strong motor sprayer, good spray deposits were had and the flies were successfully controlled. The spraying should not be done until 8 to 10 days after the flies begin to fly.--Wiesmann (170).

SIPHONAPTERA

Hectopsyllidae

Echidnophaga gallinacea (Westw.), the sticktight flea

Pulicidae

Ctenocephalides canis (Curt.), the dog flea

Ctenocephalides felis (Bouché), the cat flea

Powders containing DDT diluted to 4 or 5 percent with pyrophyllite were dusted lightly over 11 dogs, about 10 gm. being used to treat a medium-sized dog. The dog and cat fleas began to leave the host within 10 to 15 minutes; some of them died on the dogs, but most of them died on the ground within 3 to 5 hours. The sticktight fleas died on the host. Dogs treated with DDT were completely freed of fleas and protected from reinfestation for 4 to 7 days, while dogs treated with deris powder (4.8 percent rotenone) were protected for only 2 days. None of the animals showed any ill effects from the treatment.--Lindquist, Madden, and Knipling (108).

Nontechnical references

DDT kills fleas (15, 20, 141, 150, 152).

ACARINA

Argasidae

Ornithodoros megnini Duges, the spinose ear tick

A nondrying adhesive containing 5 percent of DDT was applied to the inside of the ears of 113 cattle, with no observed injury to the animals. The material gave a high kill of the ticks present at the time of treatment and afforded some protection from reinfestation.--Rude and Smith (130).

Eriophyidae

Eriophyes sheldoni Ewing, the citrus bud mite

Sprays of DDT have given encouraging results in laboratory tests.--Boyce (66).

Ixodidae

Amblyomma americanum (L.), the lone star tick

Preliminary observations indicated that DDT might be effective against ticks on vegetation. Benzene, pine oil, and xylene were each combined with

four emulsifiers, and each combination was tested with three strengths of DDT--0.2, 0.1, and 0.05 percent. Adult ticks were dipped in each mixture. In each instance the survival after 6 days was lowest (3 percent) when pine oil was used as the solvent and Areskap 50 as the emulsifier, although pine oil and B-1956 gave almost equally good results (5 percent survival).--Smith and Gouck (143).

An emulsion containing 5 percent of DDT and B-1956 applied as a wash controlled larvae of this tick on a heavily infested short-haired dog. No live ticks were found at any time, and all were dislodged by the seventh day after treatment. A spray containing 20 percent of DDT in benzyl benzoate applied to a collie was unsatisfactory. The dogs showed no ill effects from the treatment.--Gouck and Smith (90).

Amblyomma maculatum Koch, the Gulf Coast tick

DDT incorporated into a nondrying adhesive was applied to the ears of 303 range cattle, with no apparent injury to the animals. When a 2-percent DDT mixture was used, about 10 percent of the normal number of adult ticks attached to the ears, but when a 5-percent DDT mixture was used, few adult ticks were able to attach for engorgement. The 5-percent material gave a highly satisfactory kill of the ticks present at the time of treatment and afforded a high degree of protection from reinfestation for 3 weeks. This is approximately three times as long as the protection period afforded by any of the remedies now being used by the ranchmen.--Rude and Smith (130).

Ixodes ricinus scapularis Say, the black-legged tick

Benzene, pine oil, and xylene were each combined with four emulsifiers and each combination was tested with two strengths of DDT--0.02 and 0.01 percent. Adult ticks were dipped in each mixture. In each instance the survival after 6 days was lowest (0 percent) when pine oil was used as the solvent and Areskap 50 the emulsifier, although pine oil and B-1956 gave almost equally good results (3 percent).--Smith and Gouck (143).

Rhipicephalus sanguineus (Latr.), the brown dog tick

Emulsions containing 5 percent of DDT applied as washes gave satisfactory control of this tick. The emulsions were prepared by dissolving 5 parts of DDT in $6\frac{1}{4}$ parts of benzene, adding $1\frac{1}{4}$ parts of an emulsifier (B-1956), and pouring this slowly into $87\frac{1}{2}$ parts of rapidly stirred water. At the end of 10 days all the ticks on a heavily infested hound were dead. A month later the same emulsion killed all the ticks on a wire-haired terrier within 3 days. An emulsion containing 5 percent of DDT with Dreft as the emulsifier killed all the ticks on two short-haired dogs in 3 days. The same was true with a long-haired dog treated with a 5-percent DDT emulsion containing Vatsol OS. A heavily infested long-haired dog was washed in an emulsion containing 2 percent of DDT with B-1956 and Areskap. At the end of 5 days all ticks were dead except 14 engorged females (about 5 percent of the total). A cooker

spaniel infested with thousands of ticks was dusted with 10 percent of DDT in pyrophyllite. At the end of 10 days many female ticks were still alive.--Gouck and Smith (90).

Nontechnical references on ticks

DDT is highly effective against ticks infesting animals.(59), and gives some protection to man (141).

Tetranychidae

Paratetranychus pilosus (C. and F.), the European red mite

In July this mite was more abundant on apple trees sprayed with DDT than on unsprayed trees or on those to which other treatments for the codling moth had been applied. On August 24 the lady beetle Stethorus punctum (Lec.), was absent from DDT plots, but later this predator moved in and checked the threat of a severe mite outbreak.--Steiner, Arnold, and Summerland (147).

Nontechnical reference

The application of DDT in the apple orchard has resulted in the increase of the European mite (59).

Tetranychus spp., common red spiders

An aerosol mixture containing 2 percent of DDT in methyl chloride and applied at the rate of 34 gm. in a 16-cubic-foot fumigation chamber killed only 6 percent of the red spiders on bean plants and 20 percent on radish leaves within 48 hours. In another test in which 4 percent of orthodichlorobenzene plus 2 percent of DDT in methyl chloride was used, 67 percent of the red spiders were killed, but the eggs were unaffected. A spray containing 4 pounds of 5-percent DDT per 100 gallons of water killed only 13 percent within 48 hours, and a 3-percent DDT dust killed only 12 percent of the spiders.--Weigel (159).

The DDT sprays applied to apple trees apparently did not affect the red spiders. At harvest large populations were found on the fruit and under bark on all trees sprayed with DDT, while this pest was difficult to find on all the other trees.--Steiner, Arnold, and Summerland (147).

Trombidiidae

Acarisous masoni Ewing, a chigger

Eutrombicula alfreddugesi (Oud.), the chigger

Both species are pests of man. In tests against the second species in Georgia, plots 10 feet square were marked off about the bases of infested trees. In tests against the first species in South Carolina, the

plots were 10 by 20 feet and rarely included trees. The materials that gave the best control for Acariscus masoni were sulfur, dinitro-o-cresol, and 2 percent of DDT in pyrophyllite. On the first day after dusting with sulfur, chigger abundance was only 9 to 17 percent of the original infestation, and it continued to decline thereafter. In two or three tests all chiggers were eradicated in 8 days. Applications of 5-percent dinitro-o-cresol and 2-percent DDT were followed by complete absence of chiggers for 2 days, after which a few reappeared. Similar results were obtained against E. alfreddugesi.--Smith and Gouck (144).

Nontechnical references

The effectiveness of DDT against chiggers is mentioned (141, 150).

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