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Population Dynamics of Spider Mites Influenced by Ddt.

Hassan Hamed Attiah

Louisiana State University and Agricultural & Mechanical College

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INFLUENCED BY DDT.

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POPULATION DYNAMICS OF SPIDER MITES
INFLUENCED BY DDT

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

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The Department of Zoology, Physiology
and Entomology

by
Hassan H. Attiah
B. S., University of Cairo, 1939
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ABSTRACT

Build up of spider mites following DDT applications is a well known phenomenon. The harmful effect of DDT on natural enemies of mites was considered a main cause for that increase. However, many workers reported mite increases not explainable on the basis of destruction of natural enemies. Others claimed that DDT through direct effect on females cause them, or their daughters, to lay more eggs. Davis (1952) stated that DDT is irritant to mites and causes them to disperse widely and by dispersion there would follow more favorable conditions for success in survival.

The objective of this study was to gain more information concerning the effect of DDT on egg-laying, its effect on various stages and to test Davis' hypothesis. In order to test it, it was necessary to study the effect of crowding on mite population, the effect of DDT on mite dispersion and the possible effect of dispersion caused by DDT on mite population. Two species, T. telarius (L.) and T. cinnabarinus (Bois.), were used. Emulsifiable and wettable DDT in concentrations from 0.01% to 0.2% were tried.

The effect of DDT on egg-laying was studied by transferring females to treated leaves put on wet cotton in

Petri dishes. Some cultures were kept under laboratory conditions, others in a refrigerator. Results showed no increase in egg-laying rate by mothers or daughters. Rearing mites on treated leaves for 15 generations failed to increase egg-laying.

The effect of DDT on mite stages was studied by rearing mites on treated detached leaves and by spraying mite eggs directly. DDT killed early stages, irritated larvae and nymphs and delayed their reaching maturity. Emulsifiable DDT was more harmful than wettable powder.

The effect of crowding on mite population was studied by rearing mites in different densities on bean leaf discs placed on wet cotton. A negative correlation occurred between crowding and both egg-laying rate and longevity of females. A similar correlation occurred between crowding and ability to reach the adult stage. No correlation occurred between egg crowding and hatchability.

The effect of DDT on dispersion was studied by:

1. Placing females on the first leaf disc of a row of treated discs put on wet cotton.
2. Raising mite colonies on one leaf of a bean plant.
After spraying, it was attached to a series of treated plants attached by hair pins.
3. Raising mite colonies on bean seedlings with one leaf, cut into a disc without harming the petiole. Seedlings were sprayed and cemented to other treated "disc

seedlings".

In all the methods mentioned, percentages of mites which moved from the initial to different locations were determined and compared with the control, or else dispersal indexes were devised and compared. It was found that crowding was a direct cause of dispersion. DDT in higher concentrations and in emulsion caused considerable dispersion. Mites possess a negative geotropism causing them to move upwards. They could leave an infested plant or a fallen leaf to infest others by land movement.

The ultimate effect of DDT on mite populations was studied by the infestation of the first bean plant of a series of plants held in water bottles. The contiguous leaves were attached by hair pins. Infestation began with a number of females kept to form colonies before spraying. The populations were counted after two or three generations. Other experiments were done on plants grown in trays. The first row was infested by females and the total populations were counted after a certain time from spraying. DDT caused no increase in mite populations.

It is concluded that destruction of natural enemies is the main cause of mite outbreaks following DDT applications.

INTRODUCTION

Since the advent of DDT and other organic insecticides, spider mites have become of great economic importance. Treating plants with DDT to control several insects has resulted in severe outbreaks of mite infestations. The harmful effect of DDT on the natural enemies of spider mites has been considered the main cause of mite resurgences following DDT applications. Yet some workers have reported mite increases which were not explainable on the basis of the effect on natural enemies. Some workers attributed mite increases to a stimulating effect of DDT on tetranychid females causing them to lay more eggs. Davis (1952) suggested that DDT has an irritant effect on the mites causing them to disperse and by dispersion and isolation of mite colonies, there would follow more favorable conditions for success in survival. Although it has been generally accepted that use of DDT causes mite outbreaks, a few authors have reported a depressing effect of DDT on mite population.

The objective of this study was to gain more information concerning the effect of DDT on egg-laying in spider mites, its effect on various stages of the mites and to test the Davis hypothesis. In order to test this

hypothesis it was necessary to study the effect of crowding on mite population, the effect of DDT on mite dispersion and the effect of DDT on mite population.

REVIEW OF THE LITERATURE

Severe mite infestations following the use of DDT against certain insects on different hosts have been recorded by many authors in different parts of the world.

Steiner et al. (1944) reported that apple trees which were sprayed with DDT harbored higher populations of the European red mite, Panonychus ulmi (Koch), and the common red spider, Tetranychus sp. than did untreated trees.

Woody ornamentals in Ohio were subject to mite infestations which were correlated by Neiswander (1952) with the use of DDT to control other pests.

English and Tinker (1954) stated that the density of the mite Tetranychus bimaculatus Harvey on elm trees sprayed with DDT reached more than 5 times that on unsprayed trees.

Michelbacher (1959) reported that the problem of spider mites on walnut has become more acute since the advent of DDT and other newer insecticides. With the increase of dosages of DDT, there is increase in the populations of the mites, Tetranychus pacificus McGregor, Tetranychus telarius (Linnaeus) and Panonychus ulmi.

Increase of spider mites on field crops has also been recorded by many authors. Landis and Davis (1947), Gaines et al. (1952) and Michelbacher et al. (1952) have recorded

increase in mite infestations on potatoes, cotton, and melons respectively.

Some species of mites which were of no economic importance have become serious pests. Walter and Wene (1956) stated that the tetranychid mite Oligonychus pratensis (Banks) was described in 1912, but it was not until the 1950's that the mite became a real threat to grain sorghums, sweet corn and wheat in different areas. The severest infestations on sweet corn at harvest time were in those fields that had been dusted with 10% DDT for corn earworm control.

Pritchard (1953) stated that Tetranychus atlanticus McGregor became a major pest of low growing crops in California, Eotetranychus sexmaculatus (Riley) became a serious pest on avocados, and Eotetranychus uncatus Garman on apples in Massachusetts since the introduction of DDT. He also recognized that Eotetranychus lewisi (McGregor) which was described in 1943 has become an economic species.

Soil treatments with DDT (and other chlorinated hydrocarbons) were also correlated with increases in mite infestations. Klostermeyer and Ramussen (1953) stated that potatoes on field plots treated with 119 pounds or more of DDT per acre were killed by mites, whereas potatoes in adjacent untreated plots were not damaged.

Increases in mite populations following the use of DDT and other compounds have been attributed to many causes:

1. Reduction of natural enemies

Many workers have showed evidence of destructive effects on predators and parasites. Presumably spider mites succeed better in the absence of their natural enemies.

Campbell and Hutchins (1952) have studied the effects of certain insecticides (including DDT) on beneficial insects in the laboratory and in the field. Predators of the families Coccinellidae, Anthocoridae, Lygaeidae, Nabidae, Chrysopidae, Reduviidae and Mantidae which were found to be present in cotton fields, were reduced following applications of all insecticides tested.

Clancy and Pollard (1952) found that in unsprayed apple orchards, mite populations were maintained at extremely low levels by the predators. When DDT was applied, predators were killed and infestations by the mites Tetranychus bimaculatus and Tetranychus schoenei McGregor increased rapidly.

Bartlett and Ortega (1952) associated the decrease of coccinellid, lace wing and coniopterygid predators with increased populations of Tetranychus bimaculatus and Panonychus ulmi following the application of recommended dosages of DDT for the control of the codling moth on English walnut.

Fleschmer et al. (1955) reported defoliation and then complete death of the limbs of avocado trees due to large populations of the six spotted mite Eotetranychus sexmaculatus following monthly mist-spray applications of DDT which affected the natural enemies. These latter included: The lady beetle Stethorus picipes Casey, several spp. of predaceous mites of the genus Typhlodromus, the predaceous larvae of a cecidomyiid and the staphylinid Oligota oviformis (Casey).

Lord (1956) stated that when DDT was applied immediately after the bloom period in apple orchards great destruction of predators and hence rapid increases to high peaks in number of phytophagous mites occurred. Moreover, late summer applications protected mites from predators in the fall and large numbers of winter eggs were laid, which were followed by high peaks of mite population during the second year.

The effect of DDT on natural enemies is also shown by DeBach (1946), who used DDT-treated plots as checks for measuring the efficacy of entomophagous insects.

Predacious mites, especially those of the genus Typhlodromus, seem to play an important part as a limiting factor of tetranychid mites. Mathys (1958) reported the effective role of typhlodromid mites in the control of Panonychus ulmi in Swiss vineyards. Fleschner (1958) considered Typhlodromus spp. as the

most effective predators of avocado and citrus mites in southern California. Specht (1960) collected 16 spp. of Typhlodromus in New Jersey that were associated with phytophagous mites, thirteen of which were found on apple trees.

Chant (1958) studied the distribution of Typhlodromus tiliae Oudemans, a species widely abundant on apple trees in southern England, in relation to its possible effect on the European red mite. He has found that T. tiliae was distributed on the underside of the leaves along the midribs and the large subsidiary veins, while P. ulmi was uniformly distributed on the lower surface. Moreover 15-30% of the population of P. ulmi were found on the upper surface where T. tiliae seldom existed. He therefore minimized the role of that phytoseiid mite against phytophagous mites on orchards. However, Fleschner et al. (1955) have shown that typhlodromid mites on avocado "though they avoid sunlight during the day and stay on the lower surfaces of leaves, yet after sunset they begin to search both upper and lower surfaces and by midnight they might be distributed over all the leaves on the trees."

A harmful effect of DDT on typhlodromid mites was reported by many authors. Clancy and McAlister (1958) stated that these mites were affected by DDT treatments but not with glyodin and ryania sprays applied on apple

trees. They were unable to establish a positive relation between phytophagous mite increase and DDT, apart from its effect on the predators. Lord et al. (1958) revealed that the substitution of ryania for DDT after 1954 by many growers in Nova Scotia resulted in very low populations of the European red mite and the clover mite on apple trees. They attributed this to a less harmful effect of ryania than of DDT on the predators including typhlodromid mites.

Replacement of one species of Typhlodromus by another following the use of DDT and other insecticides was also indicated. Snetsinger (1959) found that on apple trees treated with DDT in central Illinois, the principal predator was T. pomi (Parrott) while in the absence of chemical treatment T. rhenanus (Oudemans) was prevalent. He stated that T. pomi which seems to be more tolerant to DDT was found to be a poorer predator than T. rhenanus. A similar situation was reported by Huffaker and Kennett (1953). They found that as a result of parathion treatment against the cyclamen mite of strawberry, T. reticulatus Oudemans, which is a very effective predator, was replaced by T. occidentalis Oudemans which is a less effective predator of the cyclamen mite than T. reticulatus.

2. Effect on plant resistance

Fleschner (1952) reported that DDT produces some change within the citrus leaves which causes a lowering of the host plant resistance. He treated citrus terminals, which were mite free, with DDT. After treatment, they were infested with mature females of the citrus red mite Panonychus citri (McGregor). He found that fewer eggs were laid on the check terminals. However, these increases in egg production could also be interpreted as increased biotic potential of the mites.

3. Effect on the mites

Hueck et al. (1952) claimed that the European red mite Panonychus ulmi lays more eggs under the influence of DDT.

Löcher (1958) has investigated the influence of DDT on the population dynamics of some tetranychids: T. urticae Koch, T. urticae f. dianthicae Dosse and Panonychus ulmi. He reported an increase in egg laying which reached 70-90% depending on the treated species. An increase in number of eggs occurred in the same generation when the egg or the larva was treated and in the next generation when the deutonymph or the adult was treated. In the case of the protonymph, increase of oviposition occurred in either the same or the next generation. A concentration as low as .0008% DDT wettable powder was sufficient to evoke stimulation.

Pielou (1960) has studied the effect of DDT on oviposition in the European red mite. No increase in the number of eggs laid by the treated females were obtained.

Attiah (1961) working with T. telarius and T. cinnabarinus (Boisduval) has not been able to confirm Locher's results. No significant differences were obtained between the numbers of eggs laid by the controls, the treated mothers and their daughters.

4. Dispersion of mite colonies

Davis (1952 b) working on the mite Tetranychus multisetis McGregor stated that DDT has an irritating effect causing the mites to move rapidly and to disperse. During this period of activity fewer eggs are laid and the mites become widely scattered over the host. The irritant effect of DDT was confirmed by Pielou (1960) and Attiah (1961). Davis suggested that dispersion of mites results in a higher reproductive potential and hence earlier mite build up. He supported his idea by his work (Davis 1952 a) in studying the effect of crowding on T. multisetis. In that work he concluded that dense populations result in a lower egg production per female and a higher percentage of non-viable eggs than occurs in a sparse population. However, Davis in that study did not compare two different populations reared under two

different crowding conditions, but he studied only one population at different intervals after starting the colony. When the colony became old, though the number of females existing was low, yet the average eggs per female was also low revealing that this low rate of egg production was not due to crowding by itself but to lack of suitable food. Non-viable eggs laid during this period could also be attributed to the same reason.

The effect of crowding on insect populations has been studied. Pearl (1932) by using eight different densities of population in Drosophila melanogaster showed that the fecundity of Drosophila diminished with increasing density of population. By daily alternations of density of population of the same identical flies he obtained the same results.

The means of dispersion of spider mites have been mentioned by many authors. McGregor (1916) stated that adult females of T. telarius are able to travel over smooth surfaces at the rate of about 5 inches per minute. "When forced to migrate through the scarcity of proper food, they commonly take to the ground and travel to other plants."

Boyle (1957) has found that "T. telarius would increase to a heavy population on a bean plant, kill the plant or hasten its death and then die on the plant or its fallen leaves without any attempt to migrate."

He found that dispersion to other plants is normally by air. Stronger wind currents are necessary to transport that species than those species that spin down such as Panonychus citri (Ebeling, 1934) and Panonychus ulmi (Fleschner, et al. 1956).

In addition to the general phenomenon that spider mites increase following the use of DDT applications, a few authors have reported a depressing effect of DDT on mite populations. Rommey (1947) obtained nearly 100% kill of mites and eggs using an emulsion containing 0.3% DDT, 0.6% benzene, 0.3% white oil and 0.01% of emulsifier against the two spotted mite T. bimaculatus (= T. urticae) on guayule.

Wingo and Thomas (1948) reported that by using an emulsion containing 0.75% or 1% DDT against the two spotted spider mite only 1% of the normal population developed on treated plants. At a concentration of 0.125% DDT emulsion, only 40-60% of the normal population developing on the check were found to develop on the treated plants. A concentration of 0.125% DDT wettable powder gave about the same results as the same concentration in emulsion formulation.

Davis (1952 b) stated that with high concentrations of DDT there is an actual mortality of some mites. He used pure DDT dissolved in acetone.

Waren et al. (1959) treated pecan trees with DDT emulsion at the rate of 1.5 pounds per 100 gallons water. A first application resulted in 100% mortality of the mites Tetranychus hicoriae McGregor and Oligonychus virdis (Banks). After one week T. hicoriae was present in numbers comparable to those prior to spraying. A second spray resulted in 100% mortality without reinfestation.

Attiah (1961) reported a decrease in the number of eggs laid by T. telarius females and an earlier death of some mites treated with high concentrations of emulsifiable DDT.

The observations of Löcher (1958) were upheld by Seifert (1962), who claimed that treated eggs, young and adults of Panonychus ulmi (which ordinarily produced one mature egg at a time before laying) eventually matured into females which produced 2 or more mature eggs at one time.

MATERIALS AND METHODS

Species of mites used:

The two species, Tetranychus telarius (L.)* and Tetranychus cinnabarinus (Bois.)* were used. Stocks were reared on beans and were first isolated from cultures maintained in the Entomological Laboratory at the Agricultural Experiment Station at Louisiana State University.

It was noticed that some of the newly emerged females were killed during the first day when exposed to DDT. For that reason the newly emerged females in stock cultures were first isolated with some males on detached bean leaves for 24 hours before being used in the experiments. No eggs were laid during that period.

DDT used and concentrations:

Commercial DDT, 23% emulsifiable concentrate, as well as 80% wettable powder (the same DDT employed by Löcher [1958] in Germany kindly furnished by Prof. Dr. G. Dosse) were used. The following concentrations were tried:

*These names following Boudreaux 1956.

0.01%	emulsion	
0.03%	"	
0.05%	"	
0.1%	"	
0.2%	"	
0.01%	wettable powder	
0.05%	"	"
0.1%	"	"
0.15%	"	"
0.2%	"	"

Methods of studying the effect of DDT on egg-laying

A detached bean leaf was placed on wet absorbent cotton in a Petri dish. Young females were transferred with a camel hair brush to the upper side of the leaf. The Petri dish was covered by a Petri dish cover to whose wall a 32-mesh plastic screen 2 inches deep was glued. This permits ventilation for both the mites and the leaf. The cultures were maintained in the laboratory where the temperature and the relative humidity were recorded by a hygro-thermograph. Fluorescent tubes* furnishing about 300 foot-candles of illumination at 21 inches to the plants for 14 hours daily were hung above the cultures. In some other experiments the cultures were placed in a refrigerator at 67° F. and 14 hours illumination, still in others the mites

*Westinghouse 40 W. Day light. Rapid start .F 40 T
12/D/RS.

were reared on detached bean leaves placed on wet cotton in jelly dishes covered with Petri dish covers. In the refrigerator experiments the effect of DDT on egg-laying at low temperatures was checked while in the jelly dishes its effect under high humidity conditions (nearly 100%) was studied. Methods of mite treatment included either treating the females on a filter paper by means of a pipette and then transferring them to untreated leaves or placing the females on treated detached leaves. To study the egg-laying of females of other generations than the treated mothers, the mites were cultured generation after generation on treated detached leaves. Females of the generation tested were placed on clean plants. In other experiments, the newly hatched larvae from eggs laid by treated mothers were transferred to clean plants. The females studied, when transferred to detached leaves, were confined to the upper surface by a tanglefoot barrier, each female to a separate area, or else ten females were placed as a group and confined to the whole surface.

In all sets of experiments undertaken, a check treatment sharing all the same circumstances, except for exposure to DDT, was performed. To prevent contamination two different camel hair brushes were used, one for DDT treatments and the other for checks. Counts of eggs were done under a binocular stereoscopic microscope. The eggs were killed with a needle after counting. Two different

needles were used.

Methods of studying the effect of DDT on various stages of the mites

Two different types of experiments were undertaken using the mite T. telarius (L.). In the first, detached bean leaves were placed on wet cotton in Petri dishes. Ten females (presumably mated) were transferred to the upper surface of each leaf and prevented from escaping by a tanglefoot barrier. The Petri dishes were covered with the screen covers previously described, and kept under laboratory conditions and 14 hours illumination with fluorescent tubes. The females were transferred every three days to new treated leaves. The eggs laid during each period were kept for the following 4 days and on the fifth day, i.e., after seven days from transferring the female, the cultures were examined. Counts were made for the dead eggs and dead larvae, live larvae and nymphs, live males and females and entangled mites (almost all those trapped in tanglefoot were larvae and nymphs). The total represented the number of eggs laid during each period.

In the second type, the females were treated with a pipette while on a filter paper and then transferred to treated plants. The females were kept for a period of 4 days and then removed. Eggs laid during that period were kept until all live mites reached the adult stage. The effect of DDT on different stages as well as its effect on

the time required for growth from egg to adult was studied.

Other experiments were performed in which the mite T. cinnabarinus (Bois.) was used. In the first, the females were kept for 4 days on treated detached leaves in Petri dishes and then removed. Three days later, the cultures were examined to determine the numbers of dead mites and entangled ones. In the second the females were kept for 24 hours on treated detached leaves, and the eggs were allowed to develop to the adult stage. Percentages of males and females appearing each day were determined. A third type of experiment was used to determine the effect of spraying of DDT directly on the eggs. The females were allowed to lay eggs on detached leaves for 24 hours and then removed. The eggs were sprayed by means of an atomizer just after the females were removed in one experiment and after 48 hours of their removal, i.e., after 72 hours from placing the females to lay the eggs in a second experiment. Percentages of dead eggs and larvae were then calculated.

Methods of studying the effect of crowding on mite population

Two different experiments were undertaken. The first experiment was designed to study the effect of the crowding of the females on the numbers of eggs laid and on the longevity of the females as well as the effect of the crowding of the eggs on their hatchability.

Detached bean leaves were cut by means of a cutting tube into discs of 1 inch diameter. A plastic sheet was cut into squares of $1\frac{1}{2}$ inches in dimensions. A circle a little less than an inch in diameter was cut from the middle of each square. The cut squares were placed on wet cotton in Petri dishes and the leaf discs were then placed on the squares so that water would be absorbed into the discs from the wet cotton while their edges laid on the plastic. Drowning of the mites or their escape in wet cotton was therefore eliminated by means of the area of plastic around the discs. Different numbers of females were placed on the leaf discs according to the different treatments. The mites were kept for 3 days on each disc and the live ones were then transferred periodically each three days to new discs. The total numbers of eggs laid by females in each of the crowding conditions were determined by counting the eggs laid during each period while the longevity of the females was determined by reference to daily records of dead mites. The eggs laid during the first two periods were kept to hatch and the percentages of unhatched eggs were determined. The data were then analyzed to study the correlations between crowding of females and numbers of eggs laid, crowding of females and longevity, and crowding of eggs and hatchability. Regressions of the numbers of eggs laid on crowding of females and the longevity of females on their crowding were

calculated.

In the second experiment the effect of the crowding of the progeny of mites on their ability to reach the adult stage was tested. Bean leaf discs of one inch diameter were placed on wet cotton. Different numbers of newly emerged females were placed on each disc for twenty-four hours in order to get different numbers of eggs, i.e., different conditions of crowding. The females were then removed and the eggs were counted. When the eggs began to hatch new bean discs $1\frac{1}{2}$ inches in diameter were prepared by cutting a circle little less than 1 inch in diameter from the middle of each. The rings formed were then placed on the wet cotton in each Petri dish around each disc. Fresh food was thus provided to the hatching larvae. Those reaching the adult stage were removed daily and the percentages of eggs which failed to reach the adult stage was calculated. The data were then analyzed to determine the correlation between and the regression of the crowding of the progeny (represented by the numbers of the eggs laid) on their ability to reach the adult stage.

Methods of studying dispersion of mites and the effect of DDT on dispersion

To test the ability of the mites to migrate from fallen leaves to cultivated plants by land movement, one bean plant was transplanted in one end of a tray measuring

9 x 12 inches, and a row of 4 plants 10 inches away was transplanted in the other end. The single plant was infested with 25 females of T. telarius, kept for 5 days and was then cut and left on the soil of the tray. The row of 4 plants was examined daily.

To test the migration of mites from an infested plant to free ones by land movement, similar experiments were undertaken without cutting the infested plant.

To study the effect of DDT on dispersion of mites, many different experiments were undertaken. In one experiment the dispersion of females on bean leaf discs 1.5 inches in diameter was checked. Five bean leaf discs were put in contact in a row on wet cotton placed in aluminum ice cube trays after being dipped in different concentrations of DDT. Twenty females of T. telarius were transferred to the first disc and then examined daily. According to the numbers of mites moving to each disc, a daily index for 8 days for each treatment was devised and the indexes were compared.

The effect of DDT on dispersion of mites from one plant to other attached plants was examined by using cut bean plants inserted through cork into water bottles. A plant of one leaf was first infested with 10 females of the species studied after placing a tanglefoot barrier around its stem. The females were kept several days to form a colony and then removed. In each treatment one set of 5 plants each as well as one infested plant was sprayed with

a different concentration of DDT while the control was sprayed with water. The bottles, after the plants had dried, were arranged in enamel pans containing water, and the contiguous leaves were pinned to each other with hair pins. After several days, the mites on the different leaves were counted. Another similar experiment was done by using different numbers of females, i.e., different conditions of crowding of the colonies.

To test the effect of DDT residue on dispersion of mites a similar technique as the previous one was used except that the infested plant was not sprayed, and after it was attached to the non-infested sprayed plants, the bottle holding the infested plant was emptied of water to compel the mites to move to the treated leaves.

Upward and downward dispersion of mites was studied by using cut bean plants having one leaf each. The leaves were cut into discs without harming the petioles. The "disc plants" were inserted through cork into water bottles, infested with ten females in each case, and then kept to form mite colonies. The infested disc plants and other uninfested ones were then sprayed with DDT in different concentrations. The plants were then cemented to each other by means of melted paraffin so that a certain number of discs were below the infested disc while others were above. Several days later the mites on different discs were counted and their dispersion under different treatments

was compared. The effect of light on upward and downward movement was tested by keeping some disc plants in continuous darkness while some others were kept under 14 hours daily photoperiod.

Methods of studying the effect of DDT on mite populations

Three different techniques were used. In the first the plants were inserted through cork into water bottles, infested with 10 females in each case, allowed to form a colony for several days and then sprayed and attached with hair pins to other plants sprayed with the same concentration. The whole population was then counted 17 days from the beginning of the experiment to test the effect of DDT on populations raised for 2 generations and after 25 days to test its effect on populations after 3 generations.

In the second technique aluminum trays 9 x 12 inches were used. The trays were planted with beans in 6 rows, four plants in each row, the plants 2 inches apart. Two leaves only were allowed to grow on each plant. In one experiment, the second plant of the first row was infested with 20 females of T. telarius. After one hour, the plants were sprayed by means of a household sprayer. Counts of the populations of the different treatments were done eleven days later. In the second experiment T. cinnabarinus was tested. Twenty females were transferred to the first row of plants, 5 females to each plant, and allowed to form

colonies for 6 days. The plants were then sprayed and the counts were done 17 days from the beginning of the experiment.

In the third technique, the effect of DDT residue on mite populations raised under two different crowding conditions was tested. Cut bean plants having one leaf each were used by cutting the leaves into discs. The disc plants were treated by being dipped in emulsifiable DDT while others were used without treatment as controls. The treated plants as well as those of the control were cemented to each other with melted paraffin so that the discs fell alternately above each other. Both the treated plants and the controls were then infested with T. telarius females placed on the lowest discs in two crowding conditions. The numbers of females used were 5 and 30. Counts of the populations were then done 14 days later.

EXPERIMENTS ON THE EFFECT OF DDT ON EGG-LAYING

Experiment 1. Effect of two concentrations of emulsifiable DDT on egg-laying by T. telarius (L.) females when isolated on treated detached bean leaves.

Procedure

Two concentrations, 0.01% and 0.03% DDT emulsion were prepared. Detached bean leaves were dipped in each concentration, allowed to dry and then placed on wet cotton in Petri dishes. The upper surface of each leaf was divided by a tanglefoot barrier into six areas, in each of which one female was transferred. The dishes were covered by the screen covers previously described and kept under laboratory conditions under the fluorescent tubes. Eggs were counted and killed daily. This experiment began on January 9, 1962 and ended on January 24, 1962. Relative humidity fluctuated between 22% and 72% and temperature between 63° F. and 82° F.

Results

Table I shows the averages of the numbers of eggs laid per female, of the eggs per day per female and of the

females' life span. No significant differences were found between the control and any of the DDT treatments.

TABLE I

Effect of two concentrations of emulsifiable DDT on egg-laying by
T. telarius (L.) females isolated on treated detached leaves*

Treatment	No. of mites	Averages**		
		Eggs/female	Days life span	Eggs/day/female
DDT 0.01%	16	167.8	22.8	7.7
DDT 0.03%	11	165.7	24.5	7.6
Control	14	155.0	22.4	7.0

*Summary of table XXXIII in the appendix.

**Analysis of variance showed no significant differences between different treatments.

Experiment 2. Effect of two concentrations of emulsifiable DDT on egg-laying by T. telarius (L.) females when kept in groups on treated detached bean leaves.

Procedure

The same procedure described in the previous experiment was used except that on each leaf ten females were placed as a group on the upper surface and confined with the tanglefoot barrier. The females were then transferred periodically to new treated leaves each 8 days. The cultures were examined daily to record the death of the females, but the counts of eggs (and larvae) were done each 4 days. Eggs and larvae were killed after each count. The experiment was done in four replications, beginning on January 9, 1962 and ending on January 26, 1962. Relative humidity fluctuated between 22% and 72% and temperature between 63° F. and 82° F.

Results

Table II shows the averages of the numbers of eggs laid per female, of the eggs per day per female and of the females' life span. No significant differences were found between the different treatments.

TABLE II

Effect of two concentrations of emulsifiable DDT on egg-laying by T. telarius (L.) females when kept in groups on treated detached leaves*

Treatment	Eggs/ 10 female**	Eggs/ female**	Days life span**	Eggs/day/ female**
DDT 0.01%	1421	142.1	20.9	7.2
DDT 0.03%	1497	149.7	21.9	7.0
Control	1609	160.9	21.9	7.4

*Averages of 4 replications presented in table XXXIV in the appendix.

**Analysis of variance showed no significant differences between different treatments.

Experiment 3. Effect of one concentration of emulsifiable DDT on egg-laying by T. telarius (L.) females when treated and kept isolated on untreated detached leaves under 67° F. and 14 hours daily photoperiod.

Procedure

T. telarius females were placed on a filter paper and then treated with a 0.01% DDT emulsion by means of a pipette, several drops on each female. Treated females were then placed on detached, untreated bean leaves put on wet cotton in Petri dishes. Number of females on each leaf was six, each confined by a tanglefoot barrier. The cultures were kept in a refrigerator at 67° F. and 14 hours illumination. The females were transferred to new leaves each five days. Eggs were counted and killed except for those which were kept to obtain first generation females. These latter when emerged were transferred to new bean leaves, six on each leaf and were kept in the refrigerator under the same conditions as their mothers. The life span of the daughters and the eggs laid by them were recorded. This experiment began on March 22, 1962 and ended on May 20, 1962.

Results

The results are shown in table III. No significant differences were obtained in the numbers of eggs laid, the longevity or the number of eggs per day per female for the females of the two different treatments in case of mothers or of the first generation females.

TABLE III

Effect of one concentration of emulsifiable DDT on egg-laying by isolated T. telarius (L.) females when kept under 67 F. and 14 hours daily photoperiod*

		Averages**		
Treatment	No. of mites	Eggs/female	Days life span	Eggs/day/female
(a) Mothers				
DDT 0.01%	10	86.9	26.6	3.3
Control	11	94.0	30.5	3.2
(b) First generation				
DDT 0.01%	9	83.2	22.6	3.5
Control	9	106.4	28.8	3.7

*Summary of table XXXV in the appendix.

**Analysis of variance showed no significant differences between the two treatments in case of mothers or of first generation females.

Experiment 4. Effect of two concentrations of DDT wettable powder on egg-laying by T. telarius (L.) females when treated and kept on treated detached leaves under high humidity conditions.

Procedure

Two concentrations, 0.05% and 0.1%, of DDT in a wettable powder formulation were prepared. T. telarius females were treated after being placed on a filter paper by means of a pipette, several drops of the suspension on each female. Treated females were then placed on detached bean leaves treated by the same concentrations of DDT, six females on each leaf and each was confined by a tanglefoot barrier. The leaves were placed on wet cotton in jelly dishes which were covered by Petri dish covers and kept on a table under the fluorescent light. To maintain high humidity conditions the covers were not removed except once each five days when the females were transferred to new treated leaves. To get first generation females, some of the eggs were allowed to hatch and the progeny were reared under the same high humidity conditions. The newly emerged females were then transferred to clean detached leaves and kept under the same conditions as their mothers. This experiment began on May 6, 1962 and ended on June 4, 1962. Relative humidity fluctuated between 54% and 82% and

temperature between 78° F. and 85° F.

Results

Table IV shows the averages of the eggs laid per female, the life span and the eggs per day per female of both the mothers and the first generation. Statistical analysis revealed no significant differences between the eggs laid, the life span and the eggs per day per female of the mothers treated with DDT and the control mothers. The same results were obtained for females of the first generation. However, there were significant differences between the number of eggs laid by the mothers and those laid by the first generation in the control as well as the 0.1% DDT treatments.

TABLE IV

Effect of two concentrations of DDT wettable powder on egg-laying by females of T. telarius (L.) when treated and placed on treated detached leaves and kept under high humidity conditions*

		Averages**		
Treatment	No. of mites	Eggs/female	Days life span	Eggs/day/female
(a) Mothers***				
DDT 0.05%	8	91.5	13.9	6.5
DDT 0.1%	9	96.9	14.6	6.7
Control	11	85.7	12.5	6.7
(b) First generation***				
DDT 0.05%	-	-	-	-
DDT 0.1%	11	40.5	10.4	4.0
Control	12	35.8	10.8	3.4

* Summary of table XXXVI in the appendix.

** Analysis of variance showed no significant differences between different DDT treatments.

*** Analysis of variance showed significant differences between the numbers of eggs laid by the mothers and those laid by the first generation females.

Experiment 5. Effect of two concentrations of emulsifiable DDT on egg-laying of various generations of T. telarius (L.) females reared continuously on treated detached leaves.

Procedure

Two concentrations, 0.05% and 0.1% DDT were prepared. T. telarius females were placed on the treated detached leaves put on wet cotton in Petri dishes. The females were confined to the upper surface of the leaf by a tanglefoot barrier and the cultures were covered by the screen cover and kept under laboratory conditions. When a new generation appeared, newly emerged females were transferred to new treated leaves. Rearing of the mites on DDT treated leaves continued for ten generations. Females of the 1st, 4th, and 10th generations were chosen to check their rate of oviposition. These females were transferred to clean detached leaves, six on a leaf confined separately by the tanglefoot barrier. This experiment began on September 7, 1961 when the parent generation was placed on treated leaves and ended on February 23, 1962.

Results

No significant differences occurred between the numbers of eggs, the life span and the numbers of eggs per day per female of the control and the DDT treatments in all

the generations tested. Results are shown in table V.

TABLE V

Effect of two concentrations of emulsifiable DDT on egg-laying of various generations of T. telarius (L.) females reared continuously on treated detached leaves*

Treatment	No. of mites	Averages**		
		Eggs/female	Days life span	Eggs/day/female
(a) First generation***				
DDT 0.05%	12	156.3	16.3	10.4
DDT 0.1%	9	154.1	16.8	9.6
Control	10	162.7	16.5	10.2
(b) Fourth generation***				
DDT 0.05%	8	165.8	16.8	11.8
DDT 0.1%	8	155.9	15.9	10.3
Control	7	164.3	21.9	7.9
(c) Tenth generation***				
DDT 0.05%	9	124.9	14.0	9.0
DDT 0.1%	9	105.6	11.3	9.4
Control	9	140.0	16.0	10.0

* Summary of table XXXVII in the appendix.

** Analysis of variance showed no significant differences between different treatments in each generation.

*** Eggs laid on untreated detached leaves.

Experiment 6. Effect of two concentrations of emulsifiable DDT on egg-laying of various generations of T. cinnabarinus (Boisduval) females reared continuously on treated detached leaves.

Procedure

The same procedure used in the previous experiment was used to study the egg-laying of T. cinnabarinus females. Generations studied were the 1st and the 15th. This experiment began on August 16, 1961 when the parent generation was placed on treated leaves and ended on April 18, 1962.

Results

Table VI shows the averages of the numbers of eggs per female, the life span and the numbers of eggs per day per female. Analysis of variance showed no significant differences between the control and the DDT treatments in both of the first and the fifteenth generations.

Experiment 6. Effect of two concentrations of emulsifiable DDT on egg-laying of various generations of T. cinnabarinus (Boisduval) females reared continuously on treated detached leaves.

Procedure

The same procedure used in the previous experiment was used to study the egg-laying of T. cinnabarinus females. Generations studied were the 1st and the 15th. This experiment began on August 16, 1961 when the parent generation was placed on treated leaves and ended on April 18, 1962.

Results

Table VI shows the averages of the numbers of eggs per female, the life span and the numbers of eggs per day per female. Analysis of variance showed no significant differences between the control and the DDT treatments in both of the first and the fifteenth generations.

TABLE VI

Effect of two concentrations of emulsifiable DDT on egg-laying of various generations of T. cinnabarinus (Bois.) females reared continuously on treated detached leaves*

		Averages**		
Treatment	No. of mites	Eggs/female	Days life span	Eggs/day/female
(a) First generation***				
DDT 0.05%	12	130.3	16.3	9.1
DDT 0.1%	10	107.2	12.1	10.2
Control	13	120.3	13.1	10.2
(b) Fifteenth generation***				
DDT 0.05%	9	147.9	16.4	9.5
DDT 0.1%	9	154.3	15.0	10.2
Control	9	129.6	15.1	8.6

*Summary of table XXXVIII in the appendix.

** Analysis of variance showed no significant differences between different treatments in each generation.

*** Eggs laid on untreated detached leaves.

EXPERIMENTS ON THE EFFECT OF DDT ON
VARIOUS STAGES OF THE MITES

Experiment 7. Effect of three concentrations of
emulsifiable DDT on various stages of
T. telarius (L.).

Procedure

Three concentrations, 0.05%, 0.1% and 0.2% emulsifiable DDT were prepared. Detached bean leaves were dipped in each concentration, allowed to dry and then placed on wet cotton in Petri dishes. Ten females were transferred to each leaf and confined as a group by the tanglefoot barrier. Two controls were used, in the first the ten females were kept as a group while in the second each female was confined to a separate area of the leaf. The females were transferred periodically each three days to new treated leaves. The cultures were examined four days later, i.e., seven days after each transfer. The whole population was counted. These included dead mites (almost all were eggs and larvae), live larvae and nymphs, live males and females and entangled mites (almost all were larvae and nymphs). The total of these represented the numbers of eggs laid in each period of 3 days. The numbers of eggs laid during all

the periods by each ten females in each treatment were obtained. The percentages of dead mites, the percentages of entangled ones and the percentages of the eggs which reached the adult stage after 7 days were calculated.

The results from the control of isolated mites were used for comparison of the life span, the numbers of eggs laid per female and the numbers of eggs per day per female. This experiment was done in four replications, beginning on August 13, 1961 and ending on September 24, 1961.

Results

Table VII (a) shows the averages of the numbers of eggs laid by the ten females in the four replications, the numbers of eggs laid per female, the life span and the numbers of eggs per day per female. Statistical analysis showed no significant differences between the different treatments.

Numbers of eggs per day per female laid during the different periods are shown in table VII (b). There was no significant interaction between the treatments and the periods, but the numbers of eggs laid during each period were significantly different.

Table VIII shows the averages of the percentages of the dead eggs and larvae, of the entangled larvae and nymphs and of the eggs which reached the adult stage during 7 days. By transferring these percentages to values as given

by Bliss (Snedecor 1959) and by statistical analysis, significant differences were found between the control and the DDT treatments at the 1% level of probability.

TABLE VII

Effect of 3 concentrations of emulsifiable DDT on T. telarius (L.) females when placed in groups on treated detached leaves

(a) Egg-laying and longevity*

Treatment	Eggs/ 10 females**	Eggs/ female**	Days life span**	Eggs/day/ female**
DDT 0.05%	1123	112.3	11.4	9.7
DDT 0.1%	1246	124.6	13.4	9.4
DDT 0.2%	1153	115.3	12.1	9.1
Control (grouped)	1323	132.3	14.1	9.7
Control (isolated)	1248	124.8	12.0	10.6

*Averages of 4 replications represented in table XXXIX (a) in the appendix.

**Analysis of variance showed no significant differences between different treatments.

TABLE VII (Continued)

Effect of 3 concentrations of emulsifiable DDT on T. telarius (L.) females when placed in groups on treated detached leaves

(b) Egg-laying in periods of 3 days*

Treatment	Eggs/day/female**				
	1st per.	2nd per.	3rd per.	4th per.	5th per.
DDT 0.05%	7.7	12.3	11.1	10.4	4.9
DDT 0.1%	8.1	13.1	10.6	9.4	5.6
DDT 0.2%	8.1	12.6	10.7	7.2	6.8
Control (grouped)	10.1	13.8	11.1	8.8	4.8
Control (isolated)	9.0	15.2	12.5	9.7	6.5

*Averages of 4 replications represented in table XXXIX (b) in the appendix.

**Analysis of variance showed no significant differences between numbers of eggs laid by females in different treatments, as averages of all periods no significant interaction between treatments and periods and significant differences between numbers of eggs laid in different periods.

TABLE VIII

Effect of 3 concentrations of emulsifiable DDT on progeny of T. telarius (L.) when kept on treated detached leaves*

Treatment	% dead eggs & larvae**	% entangled larvae & nymphs**	% reaching adult stage in 7 days***
DDT 0.05%	8.8	17.7	5.4
DDT 0.1%	11.1	27.0	4.9
DDT 0.2%	20.4	46.8	2.7
Control	3.0	5.2	20.6

*Averages of 4 replications represented in table XL in the appendix.

**Analysis of variance showed significant differences between different treatments at the 1% level of probability.

***Numbers based on exclusion of entangled mites from the total.

Experiment 8. Effect of two concentrations of DDT
wetable powder on various stages of
T. telarius (L.).

Procedure

Two concentrations, 0.05% and 0.1% DDT wettable powder were prepared. Detached bean leaves were dipped in each concentration, allowed to dry and then placed on wet cotton in Petri dishes. Ten females were treated with each concentration with a pipette while on a filter paper and then transferred to the leaf treated with the same concentration. The females were allowed to lay eggs for 4 days and then removed. The cultures were kept until all the live mites reached the adult stage. When they appeared, males and females were removed daily.

Counts of dead mites (almost all were eggs and larvae) and entangled ones (almost all were larvae and nymphs) were made. The time required for growth from egg to adult was determined. This experiment was done in four replications, beginning on April 11, 1962 and ending on May 3, 1962. Relative humidity ranged between 38% and 92% and temperature between 76° F. and 86° F.

Results

Table IX (a) shows the percentages of the dead eggs and larvae and the entangled larvae and nymphs. Tables IX

(b) and (c) show the percentages of mites reaching the female stage and the male stage in the indicated periods. Statistical analysis showed no significant differences between the different treatments.

A significant positive correlation at the 1% level of probability was found between the numbers of mites existing in each culture and the percentages of the entangled ones regardless of DDT treatment (r obtained = 0.731, r required = 0.708). Data are shown in table IX (d).

TABLE IX

Effect of 2 concentrations of DDT wettable powder on progeny of T. telarius (L.) kept on treated detached leaves. Mothers were treated and kept on treated detached leaves for 4 days and then removed

(a) Dead and entangled mites*

Treatment	Total population	% dead eggs & larvae**	% entangled larvae & nymphs**
DDT 0.05%	262.3	9.4	9.7
DDT 0.1%	328.5	7.0	15.5
Control	290.8	8.5	12.6

*Averages of 4 replications represented in table XLI (a) in the appendix.

**Analysis of variance showed no significant differences between treatments.

TABLE IX (Continued)

Effect of 2 concentrations of DDT wettable powder on progeny of T. telarius (L.) kept on treated detached leaves. Mothers were treated and kept on treated detached leaves for 4 days and then removed

(b) Time required to reach adult female stage*

Days	% reaching adult female stage**		
	DDT 0.05%	DDT 0.1%	Control
9	5.7	6.8	7.5
10	32.4	31.3	40.0
11	70.9	61.0	72.3
12	92.2	87.0	88.8
13	96.7	94.5	93.8
14	99.3	98.9	99.6
15	100.0	100.0	100.0

* Averages of 4 replications represented in table XLI (b) in the appendix.

** Analysis of variance showed no significant interaction between treatments and days.

TABLE IX (Continued)

Effect of 2 concentrations of DDT wettable powder on progeny of T. telarius (L.) kept on treated detached leaves. Mothers were treated and kept on treated detached leaves for 4 days and then removed

(c) Time required to reach adult male stage*

Days	% reaching adult male stage **		
	DDT 0.05%	DDT 0.1%	Control
9	13.3	19.6	22.1
10	51.5	58.2	55.7
11	80.5	83.7	79.1
12	96.0	93.5	93.6
13	98.2	97.0	97.3
14	99.5	99.0	99.5
15	100.0	100.0	100.0

*Averages of 4 replications represented in table XLI (c) in the appendix.

**Analysis of variance showed no significant interaction between treatments and days.

TABLE IX (Continued)

Effect of 2 concentrations of DDT wettable powder on progeny of T. telarius (L.) kept on treated detached leaves. Mothers were treated and kept on treated detached leaves for 4 days and then removed

(d) Correlation between total populations and percentages of entangled mites

Total pop. of motile stages*	% entangled larvae and nymphs*
170	1.7
200	3.5
234	7.7
246	2.8
251	2.8
268	6.3
274	3.3
302	21.2
386	35.2
387	22.2
394	26.6
414	17.5

*Statistical analysis showed a significant positive correlation at the 1% level of probability regardless of DDT treatment.

Experiment 2. Effect of DDT on various stages of
T. cinnabarinus (Bois.).

Procedure

The following concentrations of DDT were prepared:

DDT 0.05% emulsion

DDT 0.1% "

DDT 0.2% wettable powder

A detached bean leaf was dipped in each concentration, allowed to dry and then placed on wet cotton in a Petri dish.

Two different steps were followed. In the first, ten females were transferred to each leaf and kept for 4 days and then removed. Three days later the cultures were examined to determine the percentages of the dead mites and the entangled ones. In the second step, the females were kept for 24 hours only, and the eggs laid during this period were kept to reach the adult stage. In order to determine the effect of DDT on the time required to reach that stage, the cultures were examined and both males and females were counted when they appeared, and removed daily. Percentages of males and females for each date were then calculated.

The first step was done in four replications beginning on July 17, 1962 and ending on August 1st, 1962. The temperature fluctuated between 84° F. and 94° F. and the

relative humidity between 56% and 86%.

The second step was done in three replications beginning on August 29, 1962 and ending on September 6, 1962. Relative humidity fluctuated between 62% and 100% and temperature between 76° F. and 88° F.

Results

Table X represents the percentages of the dead eggs and larvae as well as those of the entangled larvae and nymphs. Statistical analysis revealed a significant difference at the 5% level of probability between all DDT treatments and the control in percentages of dead eggs and larvae and a significant difference at the 1% level of probability in percentages of entangled larvae and nymphs.

Table XI (a) shows the percentages of the females which appeared each day from the 6th till the 10th day, i.e., from the beginning till the end of the time required to reach the female stage. Statistical analysis revealed a significant interaction between the different treatments and the days.

Table XI (b) shows the data concerning the male stage. There was no significant interaction between treatments and days.

TABLE X

Effect of DDT on progeny of T. cinnabarinus (Bois.) kept on treated detached leaves. Mothers were kept on treated detached leaves for 4 days and then removed

Dead and entangled mites*

Treatment	Total population	% dead eggs & larvae**	% entangled larvae & nymphs***
DDT 0.05% E.C.	555.0	23.6	62.2
DDT 0.1% E.C.	570.3	28.3	60.2
DDT 0.2% W.P.	636.5	13.3	51.5
Control	634.8	7.3	25.7

*Averages of 4 replications represented in table XLII in the appendix.

**Analysis of variance showed significant differences at the 5% level of probability between all DDT treatments and the control.

***Analysis of variance showed significant differences at the 1% level of probability between all DDT treatments and the control.

TABLE XI

Effect of DDT on progeny of T. cinnabarinus (Bois.) kept on treated detached leaves. Mothers were kept on treated detached leaves for 24 hours and then removed

(a) Percentages of mites reaching adult female stage in days indicated*

Treatment	Total numbers of females	% reaching adult female stage in**				
		6th day	7th day	8th day	9th day	10th day
DDT 0.05% E.C.	105.3	0.0	14.2	75.4	10.0	0.4
DDT 0.1% E.C.	67.0	0.0	6.8	74.1	17.5	14.6
DDT 0.2% W.P.	159.3	0.0	31.8	57.0	10.0	1.2
Control	197.0	4.9	50.4	36.7	7.7	0.2

*Averages of 3 replications represented in table XLIII (a) in the appendix.

**Statistical analysis showed a significant interaction between treatments and days at the 5% level of probability.

TABLE XI (Continued)

Effect of DDT on progeny of T. cinnabarinus (Bois.) kept on treated detached leaves. Mothers were kept on treated detached leaves for 24 hours and then removed

(b) Percentages of mites reaching adult male stage in days indicated*

Treatment	Total numbers of males	% reaching adult male stage in**			
		6th day	7th day	8th day	9th day
DDT 0.05% E.C.	33.6	2.1	72.7	24.3	0.9
DDT 0.1% E.C.	23.3	1.7	63.4	33.6	1.3
DDT 0.2% W.P.	58.0	9.2	74.3	16.5	0.0
Control	52.0	16.1	77.6	5.7	0.6

*Averages of 3 replications represented in table XLIII (b) in the appendix.

**Statistical analysis showed no significant interaction between treatments and days.

Experiment 10. Effect of direct spray of DDT on mite eggs.

(a) Effect of DDT on eggs of T. cinnabarinus
(Bois.) treated 24 hours from the
beginning of egg-laying.

Procedure

Detached bean leaves were placed on wet cotton in Petri dishes. Ten females of T. cinnabarinus were transferred to each leaf, kept for 24 hours and then removed. Each leaf was then treated by means of an atomizer with a certain concentration of DDT while the control was treated with water. Hatching of the eggs began around 56 hours from laying, and counts of dead eggs and live larvae were done after 4 days from laying when almost all the live eggs had hatched. The following treatments were done:

DDT 0.05% emulsion

DDT 0.1% wettable powder

DDT 0.2% " "

Control

This experiment was done in 4 replications, beginning on August 10, 1962 and ending on August 17, 1962. Relative humidity fluctuated between 58% and 98% and temperature between 86° F. and 98° F.

Results

Table XII shows the percentages of dead eggs in different treatments. Analysis of variance showed significant differences at the 1% level of probability between the control and each of the DDT treatments.

TABLE XII

Effect of DDT on eggs of T. cinnabarinus (Bois.) treated 24 hours
from the beginning of egg-laying*

Treatment	Total number of eggs	Number of dead eggs	% dead eggs**
DDT 0.05% E.C.	165.5	42.5	27.3
DDT 0.1% W.P.	164.5	30.8	19.5
DDT 0.2% W.P.	147.3	26.8	23.7
Control	128.3	4.8	3.0

*Averages of 4 replications represented in table XLIV in the appendix.

**Analysis of variance showed significant differences between all DDT treatments and the control at the 1% level of probability.

(b) Effect of DDT on eggs and larvae of
T. cinnabarinus (Bois.) treated 72
hours from the beginning of egg-laying.

Procedure

The same procedure used in the previous experiment was used, except that the infested leaves were sprayed after 3 days when some eggs had hatched while the others were about to hatch. Counts of dead and live eggs and young were done two days after spraying.

This experiment was done in four replications beginning on August 14, 1962 and ending on August 20, 1962. Relative humidity fluctuated between 50% and 100% and temperature between 78° F. and 94° F.

Results

Table XIII shows the percentages of dead eggs and dead larvae. Significant differences at the 1% level of probability were found between both percentages of dead eggs and dead larvae in the control and those in all DDT treatments.

TABLE XIII

Effect of DDT on eggs and larvae of T. cinnabarinus (Bois.) treated
72 hours from the beginning of egg-laying*

Treatment	Total population	Number of dead eggs	% dead eggs**	Number of dead larvae	% dead larvae**
DDT 0.05% E.C.	120.5	68.3	57.1	23.0	19.5
DDT 0.1% W.P.	128.0	14.3	11.7	14.8	8.4
DDT 0.2% W.P.	119.5	36.0	31.9	8.3	7.1
Control	155.0	8.0	5.4	1.3	0.8

*Averages of 4 replications represented in table XLV in the appendix.

**Analysis of variance showed significant differences between all DDT treatments and the control at the 1% level of probability.

EXPERIMENTS ON THE EFFECT OF CROWDING ON MITE POPULATION

- Experiment 11. (a) Effect of crowding of T. telarius (L.) females on the numbers of eggs laid and on the longevity of the females.
- (b) Effect of crowding of T. telarius (L.) eggs on hatchability.

Procedure

Detached bean leaves were cut by means of a cutting tube to discs of 1 inch diameter. A plastic sheet was cut into squares of $1\frac{1}{2}$ inches in dimensions. A circle slightly less than an inch in diameter was cut from the middle of each square. The plastic squares were put on wet cotton in Petri dishes and the bean discs were then placed on the squares so that they could get water from the wet cotton while their edges laid on plastic. Young females of T. telarius were placed on each disc in five different crowding treatments. These were 3, 10, 20, 25, and 30 females per disc; each treatment was replicated five times. The area of plastic around each disc eliminated the drowning of the mites in wet cotton. The mites were transferred to new discs periodically every 3 days, and the eggs were

counted under a stereoscopic microscope. Longevity of the females was determined from daily records of dead ones.

To study the effect of crowding of the eggs on their hatchability, the eggs laid during the first two periods were kept to hatch. Percentages of unhatched eggs were calculated and the correlation between the crowding of the eggs and hatchability was thus determined. This experiment began on May 9, 1961 and ended on July 17, 1961.

Results

Table XIV shows the averages of the numbers of eggs per day per female and of the life span in the different treatments. Statistical analysis indicated a significant negative correlation between the number of females per disc, (and thus the number of females per square inch) and the eggs laid per day per female at the 1% level of probability (r obtained was -0.75 , r required was -0.505). A similar correlation between the number of females per square inch and the longevity of the females at the 1% level of probability was found (r obtained was -0.707 , r required was -0.505). Regression of the number of eggs laid per day per female on the number of females per square inch was -0.11 egg, while regression of the longevity of the females on the number of females per square inch was -0.16 day.

Tables XV (a) and (b) show the percentages of unhatched eggs according to the different numbers of eggs on each disc.

Statistical analysis showed no significant correlation between the hatchability of the eggs laid during the two periods and their condition of crowding.

TABLE XIV

Effect of crowding of T. telarius (L.) females on egg-laying and on life span*

Females/disc (1 inch diameter)	Females/ square inch	Eggs/day/ female**	Days life span***
3	3.8	8.0	11.9
10	12.7	7.0	7.9
20	25.5	5.7	7.5
25	31.8	5.7	7.1
30	38.2	4.8	7.0

*Averages of 5 replications represented in table XLVI in the appendix.

**Negative correlation between the numbers of eggs/day/female and the crowding of females is significant at the 1% level of probability.

***Negative correlation between the longevity of females and their crowding is significant at the 1% level of probability.

TABLE XV

Effect of crowding of T. telarius (L.) eggs on hatchability

(a) Eggs laid during first period of 3 days

Eggs/disc* (1 inch diameter)	No. of unhatched eggs	% unhatched eggs*
75	3	4.0
83	7	8.4
95	2	2.1
118	19	16.1
156	18	11.5
201	18	9.0
221	21	9.5
243	43	17.7
259	32	12.4
265	44	16.6
270	19	7.0
307	16	5.2
314	33	10.5
333	38	11.4
338	23	6.8
343	35	10.2
374	79	21.1
379	57	15.0
408	65	15.9
576	48	8.3

*Statistical analysis showed no significant correlation between the percentages of unhatched eggs and the numbers of eggs/disc.

TABLE XV (Continued)

Effect of crowding of T. telarius (L.) eggs on hatchability

(b) Eggs laid during second period of 3 days

Eggs/disc* (1 inch diameter)	No. of unhatched eggs	% unhatched eggs*
64	0	0.0
64	15	23.4
108	29	26.9
114	16	14.0
124	12	9.7
139	3	2.2
215	14	6.5
246	26	10.6
270	56	24.1
320	25	7.8
328	34	10.4
392	64	16.3
423	48	11.3
445	45	10.1
498	87	17.5
512	57	11.1
543	68	12.5
552	59	10.7
560	80	14.3
565	88	15.6

* Statistical analysis showed no significant correlation between the percentages of unhatched eggs and the numbers of egg/disc.

Experiment 12. Effect of crowding of T. telarius (L.)
progeny on their ability to reach the
adult stage.

Procedure

Bean leaf discs of 1 inch diameter were placed on wet cotton in Petri dishes. Different numbers of T. telarius females were placed on each disc for twenty-four hours in order to get different numbers of eggs, i.e., different conditions of egg crowding. After removal of the females, the eggs were counted and allowed to hatch. As the eggs began hatching new discs of $1\frac{1}{2}$ inches diameter were prepared by cutting a circle slightly less than 1 inch in diameter from the middle of each disc. The rings formed were then placed around the infested discs in order to provide fresh food for the new larvae. The discs were then kept until the mites reached the adult stage. These latter were removed daily and the percentages of eggs which failed to reach the adult stage were determined. The data were then analyzed to determine the correlation and regression of the ability of the progeny to reach the adult stage on the crowding of the eggs. This experiment began on June 15, 1961 and ended on June 30, 1961.

Results

Table XVI shows the percentages of the eggs which failed to reach the adult stage in the different crowding conditions. Statistical analysis showed a significant positive correlation at the 1% level of probability between the crowding of the progeny and their failure to reach the adult stage (r obtained was + 0.638 and the required was + 0.575). Regression of the percentages of eggs which failed to reach the adult stage on the crowding of the eggs was + 0.10% egg.

TABLE XVI

Effect of crowding of T. telarius (L.) progeny
on their ability to reach the adult stage

Eggs/disc* (1 inch diameter)	Adult produced	% of eggs failed to reach adult stage*
3	3	0.0
14	10	28.5
17	16	5.8
27	18	33.3
35	26	25.7
55	48	12.7
59	47	20.3
64	51	23.4
68	59	13.2
94	86	8.5
105	84	20.0
126	66	47.6
127	111	12.6
132	106	19.7
159	104	34.5
171	125	26.9
257	144	43.9
286	189	33.9
302	162	46.3

* Positive correlation between crowding of eggs and their failure to reach adult stage is significant at the 1% level of probability.

EXPERIMENTS ON DISPERSION OF MITES AND
THE EFFECT OF DDT ON DISPERSION

Experiment 13. Migration of T. telarius (L.) from fallen leaves by land movement.

Procedure

Four bean seedlings of two leaves each were transplanted in a tray 9 x 13 inches. The seedlings were arranged in a row 2 inches apart. A fifth seedling was transplanted 10 inches away from the previous row. The fifth seedling was then infested with 25 females of T. telarius. To prevent contamination the tray was placed in a larger enamel tray filled with water. The planted tray lay on two wooden blocks 2 inches in dimensions. After five days the infested seedling was cut and left on the ground of the tray in its place, i.e., ten inches apart from the row of 4 plants. The plants were examined daily with a pocket lens to determine the migration of the mites from the cut plant to the live ones. This experiment was done in four replications, beginning on June 1st, 1962 and ending on June 11, 1962. Relative humidity ranged between 66% and 84% and temperature between 78° F. and 84° F.

Results

Table XVII shows the daily counts of mites which migrated from the cut plant by land movement in the four replications. On June 11, 1962 the cut plants were examined. No live mites existed and only a few dead larvae were found.

TABLE XVII

Land movement of T. telarius (L.) from a cut bean seedling to a row of four seedlings 10 inches away in a tray

Replication no.	Mites on the 4 seedlings after			
	1 day	2 days	3 days	4 days
1	0	0	1 female	39 females 15 others
2	4 females	5 females	14 females 18 others*	many**
3	0	1 female	10 females 98 others	many
4	1 female	2 females	14 females 6 others	many

*Others = other stages including larvae, nymphs and males.

**Many = many of different stages.

Experiment 14. Effect of DDT on migration of spider mites from an infested plant to uninfested ones by land movement.

(a) Effect of emulsifiable DDT on T. telarius (L.).

Procedure

Eight bean seedlings of two leaves each were transplanted in 2 trays 9 x 13 inches each. The four seedlings of each tray were arranged 2 inches apart in one row. A fifth seedling of one leaf was transplanted in each tray 10 inches away from the row. Each tray was then placed on wooden blocks in a larger enamel tray filled with water. Two days later after the plants recovered from transplantation, the fifth seedling of one tray was sprayed with a concentration of 0.05% emulsifiable DDT while the second tray was used as control. After the seedling had dried, it was infested, as well as that of the control, with 25 females of T. telarius. The row of 4 plants was examined daily with a pocket lens to determine the migration of the mites from the infested seedling.

This experiment was done in three replications, beginning on July 3, 1962 and ending on July 15, 1962. Relative humidity fluctuated between 60% and 80% and temperature between 84° F. and 95° F.

Results

Table XVIII shows the numbers of mites that migrated to the uninfested seedlings after the indicated periods. Analysis of variance showed no significant differences between the numbers of migrating mites in the two treatments. There was also no significant interaction between treatments and periods.

TABLE XVIII

Effect of emulsifiable DDT on migration of T. telarius (L.) from an infested plant to uninfested ones 10 inches away by land movement

Replication no.	Numbers of females migrated after indicated periods									
	DDT 0.05%					Control				
	7 days	8 days	9 days	10 days	11 days	7 days	8 days	9 days	10 days	11 days
1	0	3	7	7	7	0	1	14	14	14
2	0	8	13	16	17	0	0	5	6	6
3	2	11	30	43	46	0	6	23	25	25
Averages*	0.7	7.3	16.7	22.0	23.3	0.0	2.3	14.0	15.0	15.0

* Analysis of variance showed no significant differences between the two treatments and no significant interaction between treatments and periods.

(b) Effect of DDT wettable powder on
T. cinnabarinus (Bois.).

Procedure

The same procedure of the previous experiment was used except that the row of the uninfested plants consisted of 3 seedlings 3 inches apart.

This experiment began on July 23, 1962 and ended on August 1st, 1962. Relative humidity fluctuated between 52% and 76% and temperature between 85° F. and 95° F.

Results

Table XIX shows the numbers of females that migrated to the uninfested seedlings after the indicated periods. No significant difference was found between the two treatments. Neither was there a significant interaction between the treatments and the periods.

TABLE XIX

Effect of DDT wettable powder on migration of T. cinnabarinus (Bois.)
from an infested plant to uninfested ones 10 inches away by land
movement

Numbers of females migrated after indicated periods												
Replication no.	DDT 0.2%						Control					
	4 days	5 days	6 days	7 days	8 days	9 days	4 days	5 days	6 days	7 days	8 days	9 days
1	0	0	7	8	13	14	1	3	4	34	55	78
2	0	1	2	15	46	83	0	0	0	0	8	13
3	0	0	0	9	22	30	0	2	2	40	70	108
Averages*	0.0	0.3	3.0	8.0	27.0	42.3	0.3	1.7	2.0	24.7	44.3	66.3

*Analysis of variance showed no significant differences between the two treatments and no significant interaction between treatments and periods.

Experiment 15. Effect of DDT on dispersion of T. telarius
(L.) females on bean leaf discs.

Procedure

Bean leaves were cut into discs 1.5 inches in diameter. Five discs were dipped in different concentrations of DDT and then placed in contact in one row on wet cotton in an aluminum ice cube tray. Twenty females of T. telarius were put on the first disc. The females were examined daily for a period of 8 days before the new generation females had emerged. A daily index of dispersion was devised according to the numbers of females which moved to each disc. This experiment was done in two steps, each in four replications. In the first the following concentrations were tried:

DDT 0.01% wettable powder

DDT 0.2% " "

DDT 0.01% emulsion

In the second step a concentration of 0.05% emulsion was tried.

The index of dispersion was obtained as follows. Each disc was assigned a multiplier value increasing with distance. Thus the disc with the original population had a value of 1, the next in line a value of 2, and so on to the 5th disc with a value of 5. The population of each disc was multiplied by the factor of the disc, and the total values for all discs were divided by the total population.

As an example, if no mite left the original disc, the dispersal index is 1. If all mites moved to the 5th disc, the dispersal index is 5. This experiment began on April 25, 1962 and ended on May 23, 1962.

Results

Table XX (a) shows the average indexes when using DDT 0.01% and 0.2% wettable powder and 0.01% emulsion. No significant differences appeared between any of the DDT treatments and the control. However, there was a significant difference between the two wettable powder treatments as average indexes of all days. No significant interaction was found between treatments and days.

Table XX (b) indicates no significant differences between the longevity of the females in different treatments.

Table XXI (a) shows the averages of the daily indexes of dispersion for a period of 8 days when using DDT 0.05% emulsion. Analysis of variance showed a significant difference at the 5% level of probability between that treatment and the control as average indexes of all days. No significant interaction existed between treatments and days.

Table XXI (b) shows the averages of the longevity of the 20 females during the period of the experiment. No significant differences occurred between the two treatments.

TABLE XX

Dispersion of 20 females of T. telarius (L.) during a period of 8 days after being placed on the first of a series of bean leaf discs treated with different concentrations of DDT

(a) Dispersal indexes*

Days elapsed	Numbers of mites existing on different discs*											
	DDT 0.01% W.P.						DDT 0.2% W.P.					
	1st disc	2nd disc	3rd disc	4th disc	5th disc	Index**	1st disc	2nd disc	3rd disc	4th disc	5th disc	Index**
1	19.3	0.0	0.0	0.0	0.0	1.0	18.3	0.0	0.0	0.3	0.0	1.1
2	17.3	1.3	0.3	0.3	0.0	1.1	14.3	0.3	1.8	1.0	1.0	1.6
3	11.3	3.3	0.8	1.0	0.0	1.5	10.3	1.5	2.3	0.3	3.3	2.1
4	6.5	6.3	1.3	0.3	1.9	5.5	3.8	1.5	1.0	5.0	2.8	3.8
5	3.8	6.3	1.0	2.5	0.3	2.3	1.3	5.5	0.8	3.3	4.0	3.2
6	1.5	3.3	4.8	2.8	0.3	2.7	1.0	3.5	2.8	2.0	2.3	3.3
7	0.5	1.8	5.5	2.3	1.3	3.1	1.3	1.3	2.5	1.8	3.5	3.6
8	0.3	1.3	3.3	1.3	3.5	3.4	1.3	1.0	2.0	1.3	2.8	3.4

TABLE XX (Continued)

Dispersion of 20 females of T. telarius (L.) during a period of 8 days after being placed on the first of a series of bean leaf discs treated with different concentrations of DDT

(a) Dispersal indexes (Continued)*

Numbers of mites existing on different discs*												
Days elapsed	DDT 0.01% E.C.						Control					
	1st disc	2nd disc	3rd disc	4th disc	5th disc	Index**	1st disc	2nd disc	3rd disc	4th disc	5th disc	Index**
1	16.8	2.3	0.0	0.0	0.0	1.2	19.3	0.5	0.0	0.0	0.0	1.0
2	14.3	3.3	1.3	0.3	0.0	1.4	16.0	0.5	0.5	0.0	2.8	1.7
3	10.0	5.3	2.0	0.0	0.5	1.7	12.5	1.3	1.3	1.0	2.3	1.9
4	5.3	5.8	3.5	0.0	0.8	2.1	4.3	6.8	3.0	1.0	1.0	2.3
5	3.0	5.0	6.8	0.8	0.0	2.4	1.8	5.3	4.5	3.8	1.3	2.8
6	2.0	1.8	5.0	3.5	0.8	2.9	1.0	2.5	2.8	3.8	2.0	3.2
7	1.5	1.3	3.0	2.8	2.3	3.4	1.5	1.5	2.8	3.3	1.8	3.2
8	1.0	0.3	1.5	1.0	2.5	3.8	1.5	0.5	0.8	2.3	3.3	3.6

*Averages of 4 replications.

**Analysis of variance showed a significant difference between dispersion indexes of the two wettable powder treatments as averages of all days but no significant differences between any of the DDT treatments and the control or between treatments and days.

TABLE XX (Continued)

Dispersion of 20 females of T. telarius (L.) during a period of 8 days after being placed on the first of a series of bean leaf discs treated with different concentrations of DDT

(b) Longevity of the females

Replication no.	Days			
	DDT 0.01% W.P.	DDT 0.2% W.P.	DDT 0.01% E.C.	Control
1	5.4	5.9	7.2	6.5
2	6.7	5.9	6.8	5.7
3	5.5	5.0	4.7	6.3
4	5.9	6.6	5.7	5.8
Averages*	5.9	5.9	6.1	6.1

*Analysis of variance showed no significant differences.

TABLE XX (Continued)

Dispersion of 20 females of T. telarius (L.) during a period of 8 days after being placed on the first of a series of bean leaf discs treated with different concentrations of DDT

(b) Longevity of the females

Replication no.	Days			
	DDT 0.01% W.P.	DDT 0.2% W.P.	DDT 0.01% E.C.	Control
1	5.4	5.9	7.2	6.5
2	6.7	5.9	6.8	5.7
3	5.5	5.0	4.7	6.3
4	5.9	6.6	5.7	5.8
Averages*	5.9	5.9	6.1	6.1

*Analysis of variance showed no significant differences.

TABLE XXI

Dispersion of 20 females of T. telarius (L.) during a period of 8 days after being placed on the first of a series of bean leaf discs treated with one concentration of emulsifiable DDT

(a) Dispersal indexes*

Numbers of mites existing on different discs*												
Days elapsed	DDT 0.05% E.C.						Control					
	1st disc	2nd disc	3rd disc	4th disc	5th disc	Index**	1st disc	2nd disc	3rd disc	4th disc	5th disc	Index**
1	19.5	0.5	0.0	0.0	0.0	1.1	20.0	0.0	0.0	0.0	0.0	1.0
2	19.3	0.8	0.0	0.0	0.0	1.1	19.3	0.0	0.0	0.0	0.0	1.0
3	19.3	0.5	0.0	0.0	0.3	1.1	17.5	1.5	0.0	0.0	0.0	1.1
4	15.3	4.0	0.0	0.0	0.3	1.3	14.8	4.0	0.0	0.0	0.0	1.2
5	7.0	9.8	1.8	0.8	0.3	1.8	9.8	6.8	0.0	0.0	0.0	1.5
6	6.3	7.5	3.3	1.0	1.0	2.1	6.3	9.3	0.0	0.0	0.0	1.7
7	2.5	7.0	5.3	1.3	1.3	2.5	3.8	6.8	2.0	0.0	0.0	2.2
8	1.3	2.5	7.3	2.5	1.0	2.7	3.3	5.8	1.3	0.0	0.0	2.4

*Averages of 4 replications.

**Statistical analysis showed a significant difference at the 5% level of probability between the indexes of the two treatments as averages of all days and no significant interaction between treatments and days.

TABLE XXI (Continued)

Dispersion of 20 females of T. telarius (L.) during a period of 8 days after being placed on the first of a series of bean leaf discs treated with one concentration of emulsifiable DDT

(b) Longevity of the females

Replication no.	Days	
	DDT 0.05% E.C.	Control
1	7.4	6.7
2	7.5	5.9
3	7.2	6.9
4	7.9	7.8
Averages*	7.5	6.8

*Analysis of variance showed no significant differences.

Experiment 16. Effect of DDT on dispersion of T. telarius
(L.) upward and downward on plants.

Procedure

A hole was bored in the center of a cork so a cut plant could be inserted through the cork and the stem could be immersed in water held in a bottle. Four cut bean plants of only one leaf each were inserted into 4 bottles. A short distance above the cork, the stem was wrapped with a piece of cotton which was then covered by Scotch tape on which a ring of tanglefoot was placed. Ten females of T. telarius were then transferred to each leaf. The mites were kept for 6 days to form a colony and were then removed. Twelve bean plants of two leaves each were prepared by cutting each leaf into a disc of 2 inches diameter without harming the petiole connecting the leaf to the stem. The tanglefoot barrier was then removed from the infested plants by removing the piece of cotton and Scotch tape from around the stem. Each infested plant was cemented with melted paraffin to 3 disc plants so that the two discs of one plant were one inch below the infested leaf while the two discs of the second plant were one inch above the infested leaf and those of the third plant were 2 inches above the infested leaf. A tanglefoot barrier was placed around the stems of each set of plants below the lowest discs. Each set was then held by a hair pin and the stems were inserted

into a bottle of water. Three concentrations, 0.01%, 0.03% emulsifiable and 0.15% wettable DDT were prepared. Three sets of plants were sprayed each with one concentration while the fourth set was sprayed with water as a control. A household sprayer was used. The bottles of plants were placed in enamel pans filled with water to prevent contamination. Four days later counting of mites existing on the different discs was made under a stereoscopic microscope. This experiment was done in three replications, beginning on May 18, 1962 and ending on May 28, 1962. Relative humidity fluctuated between 56% and 74% and temperature between 78° F. and 87° F.

Results

Table XXII (a) shows the percentages of the mites which moved to lower and upper discs in the different treatments. By transferring these percentages to values as given by Bliss (Snedecor 1959), and by statistical analysis, there was no significant differences between dispersion of mites in the different treatments as averages of percentages moving to different discs. There was also no significant interaction between treatments and levels of discs, but there were significant differences at the 1% level of probability between the percentages of mites moving to the different levels of discs, i.e., between the upward and downward movements of mites.

An index of dispersion of mites in each replication of each treatment was devised, (table XXII b), based on the numbers of mites and their location on the different discs. As the highest percentages of the mites moved to the first upper discs and the lowest percentages moved to the lower discs, a multiplier value of 2 was given to the 1st upper discs, 3 to the highest discs and 4 to the lower discs. A significant positive correlation at the 1% level of probability was found between the numbers of the mites and their dispersal indexes regardless of DDT treatment. (r obtained = 0.748, r required = 0.708).

TABLE XXII

Effect of DDT on dispersion of T. telarius (L.) colonies from an infested leaf to lower and upper uninfested discs

(a) Percentages of dispersed mites*

Treatment	Total motile stages	% of motile stages moved to		
		Lower discs**	1st upper discs**	Highest discs**
DDT 0.01% E.C.	264.3	10.4	23.5	16.2
DDT 0.03% E.C.	147.6	4.5	12.5	8.4
DDT 0.15% W.P.	224.7	2.6	12.4	16.9
Control	310.3	9.8	17.1	14.1

*Averages of 3 replications represented in table XLVII in the appendix.

**Analysis of variance showed no significant differences between different treatments as averages of percentages moving to different levels of discs, no significant interaction between treatments and levels of discs and significant differences at the 1% level of probability between percentages moving to the different levels, i.e., downward and upward movements.

TABLE XXII (Continued)

Effect of DDT on dispersion of T. telarius (L.) colonies from an infested leaf to lower and upper uninfested discs

(b) Correlation between total populations of motile stages and dispersal indexes

Total population*	Dispersal index*
111	1.68
158	2.33
174	2.53
180	2.46
192	1.94
199	2.46
236	3.20
246	3.31
266	3.80
345	3.82
366	2.89
366	3.24

*Statistical analysis showed a significant positive correlation at the 1% level of probability regardless of DDT treatment.

Experiment 17. Effect of light on upward and downward dispersion of T. telarius (L.) in the presence and absence of DDT.

Procedure

Four cut bean plants of one leaf each were used. Each leaf was cut by a cutting tube into a disc of 1.5 inches diameter without harming the petioles. The disc plants were then inserted, each through a cork into a bottle of water. A tanglefoot barrier was placed around the stem of each plant as previously described. Ten females of T. telarius were placed on each disc, left for 6 days to form a colony and then removed. Eight cut bean plants of two leaves each were prepared by cutting the leaves into discs of 1.5 inches diameter without harming the petioles. Two cut plants were then cemented with melted paraffin to each infested plant (after removing the tanglefoot barrier) so that the two discs of one plant fell 2 inches below the infested disc while the two discs of the second plant fell 2 inches above it. A tanglefoot barrier was put around the stems a short distance below the lowest discs. The four sets of plants were then inserted each into a bottle of water and were held by a hair pin. These sets were sprayed with a household sprayer, two with water as controls and two with a concentration of 0.01% emulsifiable DDT. The sets were then divided. Two were put under 14 hours daily

illumination while the other two sets were put under continuous darkness. The different treatments were thus as follows:

DDT 0.01% under 14 hours light daily

Control " " " " "

DDT 0.01% under continuous darkness

Control " " "

Three days later, the mites existing on each disc were counted under a stereoscopic microscope to determine their dispersion. This experiment was done in three replications, beginning on May 25, 1962 and ending on June 3, 1962.

Results

Table XXIII shows the averages of the percentages of mites which moved to the upper and the lower discs. There were no significant differences between DDT and control treatments under both 14 hours illumination and continuous darkness. There was a significant difference between upward and downward movement as the average of all DDT and light treatments. More mites moved up than down. There was also a significant interaction between light and direction of movement. A significant difference occurred between the percentages which moved up under the two light treatments but not between those which moved down.

TABLE XXIII

Effect of light on upward and downward dispersion of T. telarius
(L.) in presence and absence of DDT*

Treatment	Total pop.	% moved to upper discs**	% moved to lower discs**
DDT 0.01% E.C. under 14 hrs. daily illumination	296.3	65.4	1.7
Control " " " "	299.0	60.0	5.7
DDT 0.01% E.C. " continuous darkness	145.0	35.7	5.7
Control " " "	224.0	31.4	5.6

*Averages of 3 replications represented in table XLVIII in the appendix.

**Analysis of variance showed no significant differences between DDT treatments and control under both light conditions, a significant interaction between light condition and direction of movement (light affected upward movement, but not downward) and a significant difference between upward and downward movement under both light conditions.

Experiment 18. Effect of DDT on dispersion of mites from plant to plant when attached to each other.

(a) Effect of emulsifiable DDT on
T. telarius (L.).

Procedure

Four bean plants of one leaf each were inserted into four water bottles as previously described in experiment 16. After placing a tanglefoot barrier around their stems, ten females of T. telarius were transferred to each leaf. The females were kept for four days to form a colony and then removed. Twenty cut bean plants were prepared by being inserted into water bottles and by placing tanglefoot barriers around their stems. The plants were then divided into 4 groups, each consisting of one infested plant and 5 uninfested ones. Each group was then treated with a certain concentration of emulsifiable DDT by means of a household sprayer to the point of run off, while the control was treated with water. After the plants dried, they were transferred to enamel pans filled with water to prevent contamination. The bottles holding the plants of each group were arranged in a semicircle, the infested plant at first and the four plants following. The leaves of each two contiguous plants were then pinned to each other with a hair pin to ensure continuous attachment. Four days later, the leaves of each plant in each replication were

detached, one by one, and the mites existing on the lower and on the upper side were counted under a stereoscopic microscope. The percentages of the total living motile stages existing on each leaf at time of counting were determined. The percentages of dead eggs and larvae in relation to the total population in each treatment were also determined.

This experiment was done in 4 replications, beginning on December 18, 1961 and ending on January 9, 1962. Relative humidity fluctuated between 34% and 76% and temperature between 75° F. and 85° F.

Results

Table XXIV (a) shows the averages of the total population, the percentages of the adult stages, the nymphal stages and the dead eggs and larvae at the time of counting, i.e., 4 days after spraying. There was a significant difference at the 1% level of probability between percentages of dead eggs and larvae in the control and those in the DDT treatments.

Table XXIV (b) shows the average numbers of the live motile stages at the time of counting and their dispersion to the different locations as average percentages from the total of the live motile stages. Statistical analysis showed a significant difference between dispersion of mites in the control and in the 0.05% DDT treatment as average

percentages moving to all locations. There was no significant interaction between treatments and dispersion of mites to each location.

TABLE XXIV

Effect of emulsifiable DDT on dispersion of T. telarius (L.) from plant to plant when attached to each other

(a) Counts of mites 4 days after spraying*

Treatment	Total pop.	% adult stages	% larvae & nymphs	% dead eggs & larvae**
DDT 0.01%	395.5	10.4	74.4	15.5
DDT 0.03%	329.5	9.5	65.2	25.4
DDT 0.05%	322.0	8.9	56.1	35.0
Control	382.3	17.3	76.1	6.6

*Averages of 4 replications represented in table XLIX (a) in the appendix.

**Analysis of variance indicated significant differences at the 1% level of probability between all DDT treatments and the control.

TABLE XXIV (Continued)

Effect of emulsifiable DDT on dispersion of T. telarius (L.) from plant to plant when attached to each other

(b) Dispersion of mites 4 days after spraying*

Treatment	Total live motile stages	% of motile stages moved to**							
		1st leaf		2nd leaf		3rd leaf		4th leaf	
		Upper surface	Lower surface	Upper surface	Lower surface	Upper surface	Lower surface	Upper surface	Lower surface
DDT 0.01%	335.8	4.8	43.1	2.4	3.6	0.0	0.6	0.0	0.0
DDT 0.03%	247.3	7.9	37.8	3.2	3.3	0.0	0.0	0.0	0.0
DDT 0.05%	208.3	4.6	56.9	4.3	6.9	0.2	0.7	0.1	0.0
Control	356.0	5.7	31.7	1.8	0.2	0.0	0.0	0.0	0.0

*Averages of 4 replications represented in table XLIX (b) in the appendix.

**Analysis of variance showed a significant difference in dispersion between 0.05% DDT and the control as averages of all locations and no significant interaction between treatments and dispersion of mites to each location.

(b) Effect of DDT wettable powder on
T. telarius (L.).

Procedure

The same procedure used in the previous experiment was used except that 20 females were used in each treatment instead of 10 and the females were removed after 6 days instead of 4. The following treatments were tried:

DDT 0.05% wettable powder

DDT 0.1% " "

Control

This experiment was done in three replications, beginning on April 9, 1962 and ending on May 4, 1962. Relative humidity fluctuated between 40% and 82% and temperature between 78° F. and 85° F.

Results

Table XXV (a) shows the averages of the total populations, the percentages of the adult stages, the percentages of the nymphal stages and the percentages of the dead mites (almost all eggs and larvae) at the time of counting, i.e., 4 days after spraying. There were no significant differences between the control and the DDT treatments.

Table XXV (b) shows the average numbers of the live, motile stages at the time of counting and their dispersion

to the different leaves as averages from the totals. Statistical analysis showed neither significant differences between dispersion of mites in the control and in the DDT treatments as average of percentages moving to all leaves, nor a significant interaction between treatments and dispersion of mites on the different leaves.

TABLE XXV

Effect of DDT wettable powder on dispersion of T. telarius (L.) from plant to plant when attached to each other

(a) Counts of mites 4 days after spraying*

Treatment	Total pop.	% adult stages**	% larvae & nymphs**	% dead eggs & larvae**
DDT 0.05%	956.7	19.8	66.1	14.1
DDT 0.1%	825.3	20.8	63.5	15.7
Control	819.6	19.8	66.6	13.6

* Averages of 3 replications represented in table L (a) in the appendix.

** Analysis of variance showed no significant differences between different treatments.

TABLE XXV (Continued)

Effect of DDT wettable powder on dispersion of T. telarius (L.) from plant to plant when attached to each other

(b) Dispersion of mites 4 days after spraying*

Treatment	Total of live motile stages	% of motile stages moved to			
		1st leaf**	2nd leaf**	3rd leaf**	4th leaf**
DDT 0.05%	820.7	71.6	5.2	0.7	0.1
DDT 0.1%	694.3	69.4	7.7	0.3	0.0
Control	710.7	64.7	3.3	0.1	0.0

*Averages of 3 replications represented in table L (b) in the appendix.

**Analysis of variance showed no significant differences between dispersion of mites in different treatments as averages of all leaves; and no significant interaction between treatments and dispersion of mites to each leaf.

(c) Effect of DDT wettable powder on
T. cinnabarinus (Bois.) under different
crowding conditions.

Procedure

Six cut bean plants of one leaf each were prepared as previously described by placing a tanglefoot barrier around their stems after being inserted into water bottles. The plants were divided into two groups. Each consisted of 3 plants which were then infested by 5, 10 and 20 females of T. cinnabarinus respectively. The females were kept on the plants for 4 days to form colonies in different crowding conditions and then removed. Twenty four cut bean plants of 2 leaves each were then prepared by placing a tanglefoot barrier around their stems after being inserted into water bottles. Of these, 12 plants as well as the three plants of one group were sprayed with a concentration of 0.2% DDT wettable powder, while the rest were sprayed with water as controls. A household sprayer was used. The plants in bottles were then arranged in 6 enamel pans filled with water so that each infested plant was followed by four plants treated with the same treatment. Hair pins were used to attach the leaves of the contiguous plants. Counts of mites according to their locations were done four days later.

This experiment was done in 3 replications, beginning on July 25, 1962 and ending on August 14, 1962. Relative humidity ranged between 50% and 100% and temperature between 84° F. and 96° F.

Results

Table XXVI (a) shows the percentages of mites which moved to the different leaves in each treatment. Statistical analysis revealed no significant differences between the DDT treatment and the control in cases of the colonies formed by 5 and 20 females. In the case of using 10 females there was a significant interaction between treatments and dispersion to each leaf. In the DDT treatment more mites existed on the first leaf than in the control, while the contrary occurred on the 2nd, 3rd and 4th leaves.

By devising an index for dispersion according to the numbers of mites moving to each leaf and the total numbers of the moving stages in each replication in each treatment (table XXVI b), a significant positive correlation at the 1% level of probability was shown between the density of the population and its dispersion regardless of treating with DDT. (r obtained = 0.775, r required = 0.590).

TABLE XXVI

Effect of DDT wettable powder on dispersion of T. cinnabarinus (Bois.)
from plant to plant under different crowding conditions

(a) Dispersion of mites*

Treatment	Total live motile stages***	% of motile stages moved to					
		1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	6th leaf
Dispersion of a colony formed by 5 females**							
DDT 0.2%	107.3	47.8	1.0	2.2	0.2	0.0	0.6
Control	244.3	44.8	10.4	1.2	0.0	0.0	0.0
Dispersion of a colony formed by 10 females***							
DDT 0.2%	223.3	52.4	12.5	1.7	0.2	0.0	0.0
Control	420.3	27.1	33.1	12.9	0.8	0.0	0.0
Dispersion of a colony formed by 20 females**							
DDT 0.2%	397.0	26.6	22.2	17.0	0.9	0.6	0.1
Control	753.7	25.3	32.2	16.4	1.0	0.1	0.1

* Averages of 3 replications represented in tables LI (a, b & c) in the appendix.

** Analysis of variance showed no significant differences between the two treatments.

*** Analysis of variance showed a significant interaction between treatments and dispersion of mites to each leaf, on the first leaf more mites existed in the DDT treatment than the control while on the 2nd, 3rd & 4th leaves less mites existed in the DDT treatment than the control.

TABLE XXVI (Continued)

Effect of DDT wettable powder on dispersion of
T. cinnabarinus (Bois.) from plant to plant
 under different crowding conditions

(b) Correlation between numbers of populations
 and their dispersal indexes regardless of
 treatment

Total population*	Dispersal index*
53	1.51
130	1.68
139	1.66
194	1.76
221	1.77
222	1.96
223	1.72
255	1.96
288	1.41
301	2.24
357	2.13
408	2.17
432	2.26
472	2.26
482	2.47
665	2.87
793	2.31
803	2.26

*Statistical analysis showed a significant positive correlation at the 1% level of probability.

Experiment 19. Effect of DDT residue on dispersion of
T. telarius (L.) from plant to plant
when attached to each other.

Procedure

Four cut bean plants of one leaf each were prepared as previously described by placing a tanglefoot barrier around their stems after being inserted into water bottles. Ten females of T. telarius were transferred to each leaf, kept for 6 days and then removed. Sixteen cut bean plants were divided into four series of 4 plants each; three series were treated by being dipped, each in a different concentration of DDT while the fourth was not treated. The plants were then inserted into water bottles and when dried, a tanglefoot barrier was placed around their stems. The bottles containing the plants were then placed in enamel pans filled with water, and were arranged in a semicircle so that an infested plant was followed by one of the four series of 4 plants each. The leaves of contiguous plants were then pinned to each other by hair pins and, to compel the mites to move from the infested leaf to the treated plants, the bottle holding the former was emptied of water to cause the leaf to dry out. Counts of the mites on each leaf were done 6 days later. The following treatments were tried:

DDT 0.05% emulsion

DDT 0.1% "

DDT 0.2% wettable powder

Control

This experiment was done in three replications, beginning on June 8, 1962 and ending on July 3, 1962. Relative humidity fluctuated between 70% and 90% and temperature between 80° F. and 88° F.

Results

Table XXVII shows the percentages of mites which moved to the different leaves in the different treatments. Analysis of variance showed no significant differences between the DDT treatments and the control as averages of percentages of mites moved to all leaves. There was also no significant interaction between treatments and locations of mites i.e., their dispersion to each leaf. There were no significant differences between the total populations of motile stages subject to dispersion.

TABLE XXVII

Effect of DDT residue on dispersion of T. telarius (L.) from plant to plant when attached to each other*

Treatment	Total of live motile stages**	% of motile stages moved to**							
		1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	6th leaf	7th leaf	8th leaf
DDT 0.05% E.C.	527.0	39.4	29.7	15.3	6.4	2.9	3.1	1.7	1.5
DDT 0.1% E.C.	443.7	39.4	29.0	17.5	5.2	3.7	3.1	2.1	0.9
DDT 0.2% W.P.	426.0	29.1	34.5	32.9	6.8	1.6	2.7	1.3	0.2
Control	561.0	42.2	32.5	14.1	4.5	1.7	2.5	1.6	1.0

*Averages of 3 replications represented in table LII in the appendix.

**Analysis of variance showed no significant differences between the totals of motile stages, the dispersion of mites in different treatments as averages of all leaves, and no significant interaction between treatments and dispersion of mites to each each leaf.

EXPERIMENTS ON THE EFFECT OF DDT ON MITE POPULATIONS

Experiment 20. Effect of emulsifiable DDT on T. telarius (L.) populations raised for 2 generations on cut bean plants attached to each other.

Procedure

Four cut bean plants of one leaf each were prepared by placing a tanglefoot barrier around their stems and by being inserted into water bottles. Ten females of T. telarius were transferred to each plant. Six days later, 20 cut bean plants of 2 leaves each, were prepared by being inserted into water bottles and placing tanglefoot around their stems.

The plants were then divided into 4 groups. Each contained one infested plant and five uninfested ones. Three groups were sprayed by means of a household sprayer to the point of run off with different concentrations of DDT while the fourth was sprayed with water as a control. After the plants had dried, the bottles holding them were arranged in enamel pans filled with water, the infested plant at one end of a semicircle of plants. The contiguous plants were then pinned together by hair pins. Counts of the mites were

done by detaching the leaves one by one and by processing them through a brushing machine (Henderson and McBurnie, 1943). Mites brushed on the plates were counted under a stereoscopic microscope. Counts were made after 17 days from the start of infestation of leaves.

Because of limitation of space the experiment was done as randomized blocks, one replication in each block. The first replication began on March 21, 1962 and the counts were done on April 7, 1962. Relative humidity fluctuated between 40% and 78% and temperature between 76° F. and 82° F. The second replication began on March 31, 1962 and ended on April 17, 1962. Relative humidity ranged between 32% and 78% and temperature between 76° F. and 86° F. The third replication was done on April 20, 1962 and ended on May 7, 1962. Relative humidity ranged from 40% and 82% and temperature between 76° F. and 86° F.

Results

Table XXVIII shows the averages of the numbers of eggs, the numbers of the moving stages and the total numbers of the whole populations existing in each treatment after 17 days from the beginning of the infestation. Statistical analysis indicated no significant differences between the different treatments.

TABLE XXVIII

Effect of emulsifiable DDT on T. telarius (L.) population raised for 2 generations on cut bean plants attached to each other

Populations produced by 10 original females kept for 17 days*

Treatment	No. of eggs**	No. of motile stages**	Total populations**
DDT 0.01%	6065.0	2440.0	8481.0
DDT 0.03%	4356.3	1938.3	6294.7
DDT 0.05%	5614.0	2135.7	7149.7
Control	5573.7	2535.0	8108.7

*Averages of 3 replications represented in table LIII in the appendix.

**Analysis of variance showed no significant differences between different treatments.

Experiment 21. Effect of emulsifiable DDT on T. telarius (L.) populations raised for 3 generations on cut bean plants attached to each other.

Procedure

The same procedure used in the previous experiment was used, except that the mites were kept for 25 days from the start of infestation, when the populations were counted.

This experiment was done in 3 replications as randomized blocks. The first replication began on March 23, 1962 and ended on April 17, 1962, the second replication began on March 31, 1962 and ended on April 25, 1962, and the third began on May 24, 1962 and ended on June 18, 1962. Relative humidity ranged between 32% and 80% during the first replication, between 32% and 82% during the second and between 56% and 88% during the third while the temperature ranged between 75° F. and 86° F., 74° F. and 85° F. and between 78° F. and 87° F., respectively.

Results

Table XXIX shows the averages of the numbers of eggs, the numbers of the motile stages and the total numbers of the whole populations existing in each treatment after 25 days from the beginning of the infestation. Statistical analysis indicated no significant differences between the different treatments.

TABLE XXIX

Effect of emulsifiable DDT on T. telarius (L.) population raised for 3 generations on cut bean plants attached to each other

Populations produced by 10 original females kept for 25 days*

Treatment	No. of eggs**	No. of motile stages**	Total populations**
DDT 0.01%	3154.6	7133.3	10287.9
DDT 0.03%	4181.3	5550.7	9732.0
DDT 0.05%	3776.7	4131.7	7908.4
Control	5313.0	6088.0	11401.0

*Averages of 3 replications represented in table LIV in the appendix.

**Analysis of variance showed no significant differences between the different treatments.

Experiment 22. Effect of emulsifiable DDT on T. telarius (L.) populations raised for one generation on bean plants growing in trays.

Procedure

Four trays 9 x 13 inches were planted with beans in 6 rows 2 inches apart. Each row contained 4 plants 2 inches apart. The second plant of the first row in each tray was infested by 20 females of T. telarius. After 1 hour of infestation the plants were sprayed by means of a household sprayer to the point of run off, one tray with water as control, and the rest, each with a different concentration of emulsifiable DDT. The trays were then placed on wooden cubes 2 inches in diameter put in enamel pans filled with water in order to prevent contamination.

Eleven days later, the leaves of each plant were detached and the mites were counted by the use of a brushing machine.

This experiment was done in three replications as randomized blocks. The first replication began on October 7, 1961 and ended on October 18, 1961, the second began on October 22, 1961 and ended on November 2, 1961 and the third replication began on December 1st, 1961 and ended on December 12, 1961. Relative humidity and temperature were not recorded during this experiment.

Results

Table XXX shows the averages of the percentages of infested leaves, the numbers of eggs, the numbers of motile stages and the numbers of the total populations existing in each treatment. Statistical analysis revealed a significant difference in the percentages of the infested leaves between DDT 0.2% treatment and all the other treatments. Significant differences also occurred between the same treatment and all the other treatments in the numbers of eggs, the motile stages and the total populations. Differences between the control and the DDT 0.1% and 0.05% treatments were not significant.

TABLE XXX

Effect of emulsifiable DDT on T. telarius (L.) population raised for one generation on bean plants growing in trays

Populations produced by 20 original females kept for 11 days*

Treatment	% infested leaves**	No. of eggs**	No. of motile stages**	Total populations**
DDT 0.05%	45.1	3602.8	5141.2	8744.0
DDT 0.1%	47.2	3072.0	4793.2	7865.2
DDT 0.2%	56.9	2144.0	3858.8	6002.8
Control	41.7	3277.2	4744.0	8021.2

* Averages of 3 replications represented in table LV in the appendix.

** Analysis of variance showed significant differences between DDT 0.2% and all other treatments and no significant differences between the control and both 0.05% and 0.1% DDT treatments.

Experiment 23. Effect of DDT on T. cinnabarinus (Bois.)
populations raised for 2 generations on
bean plants growing in trays.

Procedure

The same procedure used in the previous experiment was used, except that the four plants of the first row in each tray were infested, each with 5 females of T. cinnabarinus placed on one leaf. Six days later, three trays were sprayed, each with a different concentration of DDT while the fourth was not treated. The different treatments were:

DDT 0.05% emulsion

DDT 0.1% "

DDT 0.2% wettable powder

Control

Counts of the populations were done 17 days from the beginning of the infestation. This experiment was done in three replications as randomized blocks. The first replication began on September 2nd, 1962 and ended on September 19, 1962, the second replication began on September 7, 1962 and ended on September 24, 1962 and the third replication began on September 13, 1962 and ended on September 30, 1962. Relative humidity during the whole periods fluctuated between 62% and 98% and temperature between 75° F. and 90° F.

Results

Table XXXI shows the average numbers of eggs, moving stages and total populations in the different treatments. Statistical analysis revealed significant differences at the 1% level of probability between the control and each of the DDT treatments concerning the motile stages and the total populations and between the control and each of the emulsifiable DDT treatments concerning the numbers of eggs.

TABLE XXXI

Effect of DDT on T. cinnabarinus (Bois.) population raised for 2 generations on bean plants growing in trays

Populations produced by 20 original females kept for 17 days*

Treatment	No. of eggs	No. of motile stages**	Total populations**
DDT 0.05% E.C.	10149.3**	9642.7	19792.0
DDT 0.1% E.C.	6618.7**	4933.3	11552.0
DDT 0.2% W.P.	13600.0	11357.3	24957.3
Control	15258.7**	17680.0	32938.7

*Averages of 3 replications represented in table LVI in the appendix.

**Analysis of variance showed significant differences at the 1% level of probability between the control and each of the DDT treatments concerning the motile stages and the total populations and between the control and each of the emulsifiable treatments concerning the numbers of eggs.

Experiment 24. Effect of residue of emulsifiable DDT on T. telarius (L.) populations raised under two different crowding conditions.

Procedure

Twenty cut bean plants of one leaf each were prepared by cutting the leaves into discs 1.5 inches in diameter. Of these, ten plants were dipped in a concentration of 0.05% emulsifiable DDT while the others were used as controls. Five plants from each group were then cemented to each other with melted paraffin so that the discs were arranged alternately above each other 1 inch apart. The plants were then infested with T. telarius females in two different crowding conditions, 5 females placed on the lowest disc in the first, and 30 females in the second. The different treatments were thus as follows:

DDT 0.05% emulsion infested by 5 females

Control infested by 5 females

DDT 0.05% emulsion infested by 30 females

Control infested by 30 females

A tanglefoot barrier was placed around the stems and the plants were then held in water bottles which were placed in enamel pans containing water. Counts of the populations were done 14 days later. This experiment was done in 3 replications, beginning on June 15, 1962 and ending on June 29, 1962. Relative humidity fluctuated between 70% and 90% and temperature between 80° F. and

86° F.

Results

Table XXXII shows the average numbers of eggs, motile stages and total populations in the different treatments. Statistical analysis revealed significant differences between the numbers of the eggs, the motile stages and the total populations of the DDT treatment and the control as averages of the two crowding conditions. There was no significant interaction between treatments and crowding conditions.

TABLE XXXII

Effect of residues of emulsifiable DDT on T. telarius (L.) population raised under two different crowding conditions

Populations counted after 14 days*

Treatment	No. of eggs**	No. of motile stages**	Total populations**
Populations produced by 5 original females			
DDT 0.05%	466.3	442.7	909.0
Control	1007.6	990.7	1998.3
Populations produced by 30 original females			
DDT 0.05%	1000.3	1471.7	2472.0
Control	1933.7	1578.6	3512.3

* Averages of 3 replications represented in table LVII in the appendix.

** Analysis of variance indicated a significant difference between the DDT treatment and the control as averages of the two crowding conditions. There was no significant interaction between treatments and crowding conditions.

DISCUSSION

In the first part of this work, experiments on the effect of DDT on egg-laying of spider mites were undertaken. In experiment 1, the effect of two concentrations, 0.01% and 0.03% DDT emulsion on T. telarius females were studied. The females were transferred to bean leaves which were dipped in the DDT emulsion and each female was kept separate from the others. The total numbers of eggs laid by each female during its life span were determined and the eggs laid per day per female were calculated. Table I shows the average results of the two DDT concentrations in comparison with the control. There was a little increase in the numbers of eggs per female, the life span and the numbers of eggs per day per female in the DDT treatments over those of the control, but statistical analysis revealed that these differences were not significant.

It was noticed that female spider mites when kept as a group on a treated leaf, tend to separate from each other, while when kept on an untreated leaf, they tend to keep close together. For this reason it was decided to find out whether the tendency of the mites to separate on the treated leaves is a factor which affects the egg-laying rate. In the second experiment each treatment consisted of

a group of ten females of T. telarius per treated leaf. Table II shows the averages of the numbers of eggs laid per each 10 females, the eggs laid per female, the averages of the life span and the eggs per day per female in the different treatments. These values were a little higher in the control than in both of the DDT 0.01% and 0.03% emulsion treatments. Analysis of variance showed that the differences were not significant, indicating that the tendency of the mites to separate from each other on a treated surface has no influence on their longevity or their egg-laying rate.

Löcher (1958) stated that exposure of the spider mite females for even 1 minute to a treated filter paper with concentrations down to 0.0008% DDT is sufficient to evoke stimulation resulting in 70-90% increase in the numbers of eggs laid by their daughters. However, Attiah (1961) has not been able to confirm Löcher's results. As the temperature in Germany where the latter's work was done is lower than that where Attiah's 1961 work was undertaken, the third experiment was planned to test the effect of DDT on egg-laying by T. telarius females at 67° F. The females were treated while on a filter paper with a concentration of 0.01% DDT emulsion by means of a pipette. They were then transferred to cut bean leaves kept on wet cotton in Petri dishes. The cultures were maintained at 67° F. and 14 hours daily photoperiod. Table III shows the rate of

egg-laying of both the mothers and the first generation females. The number of eggs laid by both the mothers and the daughters was less in the females treated with DDT than in the control. However, the differences were not significant. The longevity of both the mothers and the daughters was also shorter in the DDT treatment than in the control but the differences were also insignificant.

In the fourth experiment the effect of DDT wettable powder on both the mothers and the first generation females of T. telarius under high humidity conditions was checked. The mites were treated by means of a pipette and then transferred to treated leaves which were put on wet cotton in jelly dishes covered with Petri dish covers. Relative humidity in the dishes reached around 100%. There was no significant difference between the numbers of eggs laid by the treated mothers and the control as shown in table IV. The longevity of the females was also approximately the same. The same results were obtained with the females of the first generation. However, there were significant differences between the numbers of eggs laid per female and the eggs laid per day per female by the mothers in both the control and the DDT 0.1% treatment and those laid by the first generation females. The daughters in both treatments laid less than half the number of eggs laid by their mothers, but their life span was nearly equal. These results show that the females which were reared under high humidity conditions lay half as many eggs as those laid by females

reared under drier conditions. Relative humidity around the stages reared to produce the mothers fluctuated between 40-80% while the daughters were reared under humidity conditions reaching 100%. Emulsifiable DDT was not tested under these conditions.

In the fifth and sixth experiments the effect of emulsifiable DDT on egg-laying by both T. telarius and T. cinnabarinus females reared continuously generation after generation on treated leaves was checked. In the fifth experiment two concentrations, 0.05% and 0.1% DDT emulsion, were tried on T. telarius. Rearing the mites for 10 generations failed to evoke any increase in egg-laying. The generations checked were the 1st, 4th and 10th. Females of the previous generations were transferred to lay eggs on untreated leaves when compared with the control. In experiment 6, T. cinnabarinus was used. The same results were obtained when rearing the mites for 15 generations. Tables V and VI show the results of the two experiments.

Seifert (1962) stated that the effect of DDT on the treated females causing a change in the structure of the ovary, is perceptible two or three weeks after treatment, and because of the short life remaining, many different authors could not demonstrate the increased fertility. However, as already shown in experiment 3, no increase in egg-laying was obtained by the mothers or the first generation females when reared in a refrigerator at 67° F.

In that experiment the first generation females emerged 21 days from the date of treating their mothers. Their life span averaged 22.6 days showing that, during a period of 43.6 days there was no increase in the egg-laying rate. The same results were obtained by the females of T. telarius during a period of 166 days in experiment 5, and of T. cinnabarinus during a period of 240 days in the 6th experiment.

In summary, in no case was it possible to get any increase in egg-laying in spider mites by using DDT, (W. P. or E. C.) either in the treated mites or in the following generation. Moreover, rearing mites continuously on DDT treated leaves failed to stimulate the egg-laying rate.

In the second part of this work, the effect of DDT on the mites was studied. In experiment 7, T. telarius females were kept in groups of 10 mites on leaves treated with emulsifiable DDT. Two controls were used. In the first, 10 mites were kept as a group on the leaf, while each of the 10 females was confined to a separate area of the leaf in the second control. The mites were transferred every three days to bean leaves treated with the same treatments. Table VII (a) indicates that there were no significant differences in the egg-laying rate or in the longevity of the females in the different treatments. These results confirm the results obtained in the previous experiments. The numbers of eggs laid during each period

of 3 days in the different treatments are shown in table VII (b). Though the numbers of eggs laid by the females of all the DDT treatments were less than those laid by the females of both the isolated and the grouped controls during the 1st and the 2nd periods, yet statistical analysis showed no significant interaction between treatments and periods. It was therefore concluded that DDT had no effect on egg-laying rate in each period. Davis (1952 b) had studied the effect of DDT on egg-laying of T. multisetis McGregor (T. cinnabarinus). He concluded that DDT in acetone caused a drop in the egg production during the first period of 4 days, but during the second 4 days period the egg production increased greatly and by the third period of 3 days the egg production was equal to the check. Davis gave no indication of having analyzed his results statistically.

In the same experiment the effect of DDT on the progeny of T. telarius raised on treated leaves was studied. Table VIII indicates that a decided harmful effect on both the eggs and the larvae was caused by emulsifiable DDT. The higher the concentration, the higher the percentages of dead mites in the early stages. Irritation to the larvae and nymphs is clearly shown by the higher percentages which were caught in the tanglefoot barrier in all DDT treatments compared to the control. Again the higher the dose, the higher the number of entangled mites. Percentages of the mites which reached the adult stage during a period

of 7 days are indicated in the same table. These percentages were calculated on the basis of exclusion of the entangled mites from the total population. Fewer mites reached the adult stage in the DDT treatments than in the control, the higher the concentration the fewer the adult mites. Statistical analysis showed that the differences between the DDT treatments and the control in the percentages of the dead eggs and larvae, the entangled larvae and nymphs and the percentages of the mites which reached the adult stage in 7 days were all significant at the 1% probability level.

In the 8th experiment the effect of two concentrations, 0.05% and 0.1% DDT wettable powder, on T. telarius was tested. The mites were treated and transferred to treated plants where they stayed for 4 days and then were removed. The progeny were kept until all the live ones reached the adult stage. The percentages of the dead eggs and larvae and the entangled larvae and nymphs are shown in table XI (a). There were no significant differences between the DDT treatments and the control, but there was a significant correlation at the 1% probability level between the percentages of the entangled mites and the total populations, revealing that crowding of the progeny was the factor that caused the mites to escape and to get caught in the tanglefoot barrier, while DDT wettable powder in the concentrations used had no irritant effect on the mites.

Tables IX (b) and (c) show that the time required to reach the adult stage was from 9 to 15 days when 100% of the mites reached that stage. However, higher percentages of males reached that stage in 9 days than the percentages of the females. Analysis of variance showed no significant interaction between treatments and days, neither in the times required to reach the female stage nor in those required to reach the male stage.

The effect of DDT on progeny of T. cinnabarinus was tested in experiment 9. Table X shows the percentages of the dead eggs and larvae in the different treatments. There was a significant difference between all the DDT treatments and the control. Emulsifiable DDT is more harmful to mites than is the wettable powder formulation. With a concentration of 0.05% emulsion the percentage of the dead eggs and larvae reached 23.6 while it was only 13.3% when using a 0.2% wettable powder. The difference between the two treatments was significant.

Irritation to the larvae and nymphs is represented by the percentages which were entangled. In the previous table higher percentages were entangled in all DDT treatments than in the control. The differences were significant at the 1% probability level. A concentration of 0.05% emulsion was more irritant to the larvae and the nymphs than a 0.2% wettable powder. A significant difference occurred between the percentages of the entangled mites in the two

treatments.

Table XI (a) shows that the time required to reach the female stage was 6 to 10 days in all treatments, though higher percentages reached that stage in the 6th and 7th days in the control than did the females in all the DDT treatments. Accordingly, higher percentages of females reached that stage in the 8th, 9th and 10th days in the DDT treatments than in the control. This interaction between treatments and days was significant. The same trend occurred concerning the male stage though statistical analysis showed that the interaction between treatments and days was not significant. DDT wettable powder is still less effective than emulsifiable concentrate in regard to delaying the mites in reaching the adult stage.

Delay in reaching the adult stage caused by DDT might be a result of the death of the early hatching eggs, or might be attributed to non-viability of the eggs which were laid early when the mites were in contact with a freshly treated surface.

The effect of spraying mite eggs with DDT on both the eggs and the larvae was tried in the tenth experiment. In experiment 10 (a), T. cinnabarinus eggs were treated 24 hours after the beginning of egg-laying by means of an atomizer. The cultures were examined 4 days after treatment when all the live eggs had hatched. As shown in table XII many eggs were killed, but very few dead larvae were

encountered in all the different treatments revealing that DDT applied several days before hatching had no effect on killing newly hatched larvae. The highest percentage of dead eggs occurred when the eggs were treated by 0.05% emulsifiable DDT. Wettable powder formulation in 0.1% and 0.2% was less harmful to the eggs than the emulsifiable treatment. Analysis of variance showed that the differences in the percentages of dead eggs between the control and each of the DDT treatments were significant at the 1% level of probability. In experiment 10 (b) the eggs were kept 72 hours before treatment, when some of the eggs had hatched and the others were about to hatch. DDT in that case was more effective on the eggs than when treated after 24 hours. Higher percentages of the eggs were killed and so were many larvae. Data shown in table XIII indicate that DDT wetttable powder was less harmful to the eggs and the larvae than was the emulsifiable form. Statistical analysis revealed that the differences between all the DDT treatments and the control concerning percentages of dead eggs and dead larvae were significant at the 1% level of probability.

To summarize the results of the effect of DDT on various stages of mites it was found that.

1. DDT had a harmful effect by killing the early stages.
2. DDT had an irritant effect to the larvae and nymphs causing them to be caught in the tanglefoot.
3. DDT caused delay in reaching the adult stage.

4. DDT in the percentages used, had no effect on the egg-laying rate either over the entire egg-laying period or during the first few days.
5. Emulsifiable DDT was more effective on the mites than wettable powder. A concentration of 0.05% of the former was more harmful than 0.2% of the latter. Treating the mites with 0.1% wettable powder did not show the mentioned effects but spraying mite eggs with that concentration killed many eggs and larvae.

In another part of this study, the effect of crowding on mite population was studied. In experiment 11, T. telarius females were placed on bean leaf discs in 5 different crowding conditions. The eggs laid during the whole life of the females in each condition were counted and the numbers of eggs per day per female were calculated. The longevity of the females was determined by the daily mortality records. As shown in table XIV, there was a significant negative correlation between the crowding of females and both their longevity and the number of eggs laid per day per female. The regression of longevity on crowding was - 0.16 day while the regression of the eggs laid per day per female on crowding was - 0.11 egg. When the eggs laid on bean leaf discs in different crowding conditions were kept to hatch, no significant correlation between hatchability and crowding was found. These results were obtained from eggs laid during 2 periods of 3 days

each. Data for the two periods are shown in tables XV (a) and (b).

Crowding of mite progeny affected their ability to reach the adult stage. In experiment 12, different numbers of females of T. telarius were placed on bean leaf discs in order to get different numbers of eggs per each unit of leaf surface. The eggs were allowed to develop to the adult stage. There was a significant positive correlation between the crowding of the progeny and the percentages of the eggs which failed to reach the adult stage. The regression on the crowding of the progeny was $+ 0.1\%$ egg. Figures are shown in table XVI.

An indication of the effect of crowding on dispersion of mites was obtained in experiment 8, where a significant positive correlation at the 1% level of probability was found between the crowding of T. telarius populations on bean leaves surrounded by a tanglefoot barrier and the percentages of the mites which were caught in that barrier. More indications revealing that crowding is a cause of dispersion will be shown in later experiments.

In the 4th part of this work, experiments concerning dispersion of mites and the effect of DDT on dispersion were undertaken. In experiment 13, the ability of the mites to migrate from fallen leaves and infest other plants via the ground was tested. A bean seedling was infested with 25 females of T. telarius. Five days later it was cut and left

on the ground 10 inches away from a row of 4 bean plants free from infestation. The experiment was repeated four times. In the first replication migration began after 3 days (from cutting the infested plant), when one female was found on one plant of the row. On the following day 39 females and 15 other stages were found. In the second replication migration took place during the 1st day after cutting the infested plant by four females which infested the free row. Three days later, the latter was highly infested by all stages of mites. In the third replication one female was found on one plant of the row, 2 days from cutting the infested plant. On the following day 10 females and 98 other stages were found. In the 4th replication migration began during the first day by one female. By the fifth day, i.e., four days after cutting the infested seedling, the free row was infested by many of the different stages. Data are shown in table XVII.

In the fourteenth experiment the ability of spider mites to desert an infested plant and infest others taking the ground route, and the effect of DDT in that connection was tested. In experiment 14 (a) emulsifiable DDT was tried with T. telarius. Table XVIII shows the numbers of females which migrated after the periods indicated. Migration from the infested seedling began 7 days after the infestation in the DDT treatment and 8 days in the control. It is of interest to state that migration began when the new

generation of females appeared. Eleven days from the beginning of the infestation an average of 23.3 females and 15.0 females had migrated to the free row in the DDT treatment and the control, respectively. Statistical analysis showed no significant difference between the control and the DDT treatment as an average of mites migrated during the total period. There was also no significant interaction between treatments and days. Similar results were obtained in experiment 14 (b) by using T. cinnabarinus and wettable DDT. Very few females migrated to the free plants before the new generation appeared. Females of the latter appeared 6 days after the initial infestation with the mothers. As shown in table XIX, nine days from the beginning of the infestation an average of 42.3 and 66.3 females were found on the free row in the DDT and the control treatments respectively.

These results confirm that spider mites in search of nourishment and space could move on land by quitting a heavily infested plant or fallen leaf to infest other plants. Boyle (1957), stated that laboratory and field experiments have shown that mites do not use the ground route as means of dissemination.

In experiment 15, the effect of DDT on dispersion of T. telarius females was studied. Bean leaf discs were placed in contact on wet cotton, in one row. Twenty females were put on the first disc and were examined for 8 days to

determine their location on the different discs. An index system of dispersion was devised as previously described and the daily indexes of the different treatments were compared. DDT wettable powder in the concentrations used, 0.01% and 0.2% had no more effect on dispersion than that in the control. A significant difference occurred between a 0.05% emulsifiable DDT and the control as average indexes of all days but no significant interaction between treatments and days was found. The results are shown in tables XX (a) and XXI (a). There was no significant difference between the longevity of the females in the different treatments as shown in tables XX (b) and XXI (b).

Experiment 16 was designed to test the effect of DDT on upward and downward dispersion of T. telarius on the plants. An infested bean seedling was cemented by paraffin to other uninfested seedlings whose leaves were cut into discs. The whole set was prepared so that 2 discs were 1 inch below the infested leaf, 2 discs were 1 inch above that leaf and 2 others were 2 inches above it. Spraying with wettable DDT 0.15%, or emulsifiable DDT 0.01% and 0.03% did not cause any greater increase in dispersion of mites than happened in the control. Table XXII (a) shows the averages of the total numbers of the moving stages subject to dispersion in the different treatments and the average percentages of the mites which moved to the different discs. In all the treatments the lowest percentages moved to the lower discs,

higher percentages moved to the highest discs and the highest percentages were found on the 1st upper discs. The differences between these percentages as averages of all treatments were significant at the 1% level of probability. These results indicate that the mites in their dispersion on an infested plant prefer to move up rather than down. There was also no significant interaction between DDT treatment and direction of movement. Moreover, dispersion of the mites was found to be a direct response of crowding of the populations rather than a response to the DDT. As shown in table XXII (b) a significant positive correlation at the 1% level of probability occurred between the numbers of the populations in the different cultures and the dispersal indexes.

Experiment 17 was then planned to find out whether the upward movement of the mites is a response to light, i.e., a positive phototropism. T. telarius females were transferred to bean seedlings having only one leaf each. That leaf was cut into a disc 1.5 inches in diameter before being infested. Six days later, the seedlings were cemented to other "disc seedlings" so that two discs fell 2 inches below the infested disc and two discs 2 inches above it. Four different sets existed, two were treated with DDT and the two others were not treated to serve as controls. Of these one treated and one untreated set were kept under continuous darkness while the two similar sets were kept

under 14 hours light daily. Three days later the motile stages existing on the different discs were counted and the percentages of total which moved to the upper and to the lower discs were calculated. As shown in table XXIII very low percentages, ranging from 1.7 to 5.7, moved to the lower discs in all treatments. The great majority of the mites moved upwards, but the percentages which did so under the light treatment as averages of treated and untreated treatments were nearly twice as great as those under continuous darkness. These conclusions reveal that the upward movement of the mites can be considered a negative geotropism since, under continuous darkness, around 40% of the mites moved upward and only around 6.0% moved downward. However, light was a factor which activated that movement. Around 65% of the mites in the light treatment moved upward, in comparison with 40% in the dark treatment. Downward movement was not affected by light. Percentages which moved down were nearly equal under both light conditions. This interaction between light and movement direction was significant at the 1% probability level. Our knowledge of the habits of the two species T. telarius and T. cinnabarinus in preferring the lower surface of the leaf to the upper surface might add to the evidence that upper movement of the mites is not a positive phototropism.

DDT in the concentration used, 0.01% emulsion, had no effect on dispersion. No significant difference was found

between DDT and control treatments as the average of percentages of dispersed mites under all other conditions.

The effect of DDT on the dispersion of mites from plant to plant when their leaves come in contact with each other was tested in the eighteenth experiment. Emulsifiable DDT in the concentrations 0.01%, 0.03% and 0.05% was tried with T. telarius. Ten females were allowed to lay eggs on the leaves of cut bean plants of one leaf each. After 4 days the females were removed and all the plants except control plants were treated with DDT. Plants treated with the same treatment were arranged side by side and the leaves of the contiguous plants were pinned with a hair pin. Four days later the whole populations were counted according to their different locations whether on the upper or on the lower side of each leaf. The average percentages of the dead eggs and larvae, the live nymphal stages and the live adults in each treatment were calculated. Table XXIV (a) shows the results. A significant difference at the 1% probability level was found in the percentages of the dead eggs and larvae between all the DDT treatments and the controls. Fewer adults were found in the DDT treatments than in the control. These results agree with the previous results of the effect of DDT on mite stages. To determine the effect of DDT on the dispersion of the mites, the average percentages of the moving stages which moved from the original infested leaf to the upper and the lower side of

each of the successive leaves in relation to the total population of the live motile stages existing in each treatment were calculated. Analysis of variance showed a significant difference between the control and the DDT 0.05% treatment as averages of percentages of mites which dispersed to all locations. There was no significant interaction between treatments and dispersion of mites to each location. Data are shown in table XXIV (b). The counts of mites were done 4 days after treatment and when the colonies were 8 days of age. Adult mites at that time ranged from 8.9% in the 0.05% DDT to 17.3% in the control, while the nymphal stages ranged from 56.1% to 76.1% respectively in the mentioned treatments (table XXIV a).

In experiment 18 (b), two concentrations of DDT wettable powder, 0.05% and 0.1% were tried with T. telarius. The females were kept to form colonies for 6 days before treatment. The counts were done 4 days later. As shown in table XXV, there were no significant differences between the control and the DDT treatments concerning the percentages of the dead mites, the live nymphal stages and the live adults in relation to the total populations existing 10 days from the start of the colonies. These results confirm what already occurred in the experiments of the effect of DDT on various mite stages. There was also no effect of the concentrations used of wettable DDT on the dispersion of the mites. Table XXV (b) indicates no significant differences

between the different treatments.

In experiment 18 (c) the effect of a higher concentration of DDT wettable powder, 0.2%, was checked against T. cinnabarinus colonies reared in different densities. As shown in table XXVI, there were no significant differences in dispersion of the colonies formed by both 5 and 30 females between the DDT treatment and the control as averages of the percentages of mites which moved to different leaves, neither was there an interaction between treatments and dispersion to each leaf. In case of the colonies formed by 10 females there was a significant interaction between treated and untreated mites and their dispersion to each leaf. On the first leaf higher percentages existed in the DDT treatment than in the control. The contrary occurred in case of the 2nd, 3rd and 4th leaves. In other words, dispersion of mites was greater in the control than in the DDT treatment. Examination of the previous table indicates that this higher dispersion was a result of higher population in the control than in the DDT treatment. A close similarity in the trend of dispersion of the mites occurred in case of the following treatments:

DDT 0.2% on the colony formed by 5 females

Control " " " " " "

DDT 0.2% " " " " " 10 "

The average populations of these treatments which were subject to dispersion were 107.3, 244.3 and 223.3. The

populations of the remaining treatments dispersed also, on the different leaves, in a similar manner. Their average numbers were 420.3, 397.0 and 753.7. These conclusions were verified by devising dispersal indexes to the different populations. Table XXVI (b) indicates a significant positive correlation at the 1% level of probability between the numbers of populations and their dispersal indexes regardless of DDT treatment. It was also clear that spraying the colonies four days after placing the mothers with a concentration of 0.2% wettable DDT had a harmful effect on the progeny. The numbers of the populations in the treated colonies in the 3 different densities, 4 days after spraying, were less than in the controls. The differences were significant.

In experiment 19, the effect of DDT residue on the dispersion of T. telarius from plant to plant when in contact with each other was studied. The colonies of the mites were formed on untreated leaves and were forced to leave them to treated ones by causing the former leaves to dry out. Table XVII shows that there were no significant differences between the dispersion of the mites in the different treatments. Though the percentages of DDT used in that experiment were high enough to be harmful to the progeny, yet the numbers of the populations in all the DDT treatments, i.e., 0.05% and 0.1% emulsion and 0.2% wettable powder were not significantly different from those in the

control. The reason might be that the mites tended to remain on the untreated leaf and by the time the mites were forced to move to the treated plants, the residue of DDT on the leaves was harmless to them. Attiah (1961), showed that spider mites avoid surfaces treated with DDT.

To summarize the previous experiments on the dispersion of mites affected by DDT, it was found that:

1. Spider mites could leave a fallen leaf or a severely infested plant and walk on the ground to infest other plants.
2. Dispersion of the mites is directly correlated with the density of the colonies.
3. Mites possess a negative geotropism causing them to move upwards rather than downwards. This upward movement could be activated by light.
4. DDT in the wettable powder formulation in the concentrations used which ranged from 0.01% to 0.2% did not show any effect on mite dispersion either on females or on other stages.
5. DDT in the emulsifiable formulation in a concentration of 0.05% caused dispersion of the females as well as the other stages. Concentrations of 0.03% and 0.01% had no such effect.
6. Residue of DDT of a 0.05% emulsion did not cause more mites to leave a treated plant and infest other uninfested ones 10 inches away. Moreover, residues of

the same formulation of 0.05% and 0.1% had no effect on dispersion of mites arriving from an untreated attached plant.

In the last part of this study, experiments on the possible effect of dispersion caused by DDT on mite population were undertaken. Experiment 20 was designed to study the effect of spraying a colony of T. telarius 6 days old with emulsifiable DDT on the reproduction of the mites raised for 2 generations on attached plants. As the new generation took around 8 days to appear at the time the experiment was done, counts of the mites were done 17 days from the start of the colony. As shown in table XXVIII there were no significant differences in the numbers of eggs, the moving stages and the total populations between the control and the DDT treatments in the concentrations used, 0.01%, 0.03% and 0.05%.

In experiment 21 the effect of emulsifiable DDT on growth of T. telarius populations raised for 3 generations was tested. Counting of the mites was done 25 days from the start of the colonies and 19 days from spraying with DDT. Table XXIX shows that the average of the total populations in the control was higher than in any of the DDT treatments. In the latter, the higher the concentration the lower was the average. But statistical analysis revealed that these differences were not significant. There were also no significant differences in the numbers of eggs

and in the numbers of the motile stages between the control and the DDT treatments.

Experiment 22 was designed to study the effect of DDT on mite populations on plants grown in trays. The plants in each tray were infested by 20 T. telarius females placed on the second plant of the first row. One hour after infestation the plants were sprayed with DDT emulsion. Counts of the mites as well as of the infested leaves were done eleven days later, i.e., after the new generation of mites was formed. It was clear, as shown in table XXXI that DDT emulsion caused more dispersion in the mite populations than it did in the untreated check, represented by the higher percentages of the infested leaves in all the DDT treatments than in the control. However, statistical analysis showed that the differences between either 0.05% or 0.1% DDT and the control were not significant. But the average percentage of the infested leaves in the DDT 0.2% was significantly higher than the averages in the other treatments including the control. Concerning the numbers of eggs, the motile stages and the total populations of mites produced in the different treatments, the lowest numbers occurred in the DDT 0.2% treatment. Differences between that treatment and each of the other treatments were significant, but those between either 0.1% or 0.05% and the control were not significant. These results indicate that DDT 0.2% emulsion caused a higher dispersion of the mites than occurred in the control but in the mean

time it caused a great harm to the progeny which resulted in lower populations produced during 11 days from the beginning of the infestation.

In experiment 23, the effect of both emulsifiable and wettable DDT on the reproduction of T. cinnabarinus was tested. Twenty females were kept to form colonies on a row of 4 bean plants in each treatment. The plants were grown in trays, each contained 24 plants in 6 rows. Six days after the start of the infestations spraying was done in the different treatments except the control. Counts of the mite populations were done eleven days later. DDT treatments, as shown in table XXXII, resulted in lower populations than those produced by untreated mites. Emulsifiable DDT produced lower populations than did the wettable powder in spite of the lower dosages used of the former than the dosage used of the latter. The differences between the total populations in the control from those in the DDT treatments were significant at the 1% level of probability. Concerning the motile stages, the differences between those produced in the control and those in all the other treatments were also significant. But the difference in the numbers of eggs between the control and the 0.2% wettable DDT was not significant while it was significant between the control and each of 0.05% and 0.1% emulsion. The reason might be that the egg-laying rate of the females was reduced in the control in comparison with the wettable

DDT when the mites were crowded by a higher population in the former. The low egg numbers produced in the emulsifiable DDT treatments were comparable to the low populations produced as a result of the harmful effect of DDT on the colonies.

The effects of DDT on mite populations when raised under different densities were studied in the last experiment. The same amounts of food and space were provided for the reproduction of 5 and 30 females by using "disc plants" as previously described. These plants were treated with 0.05% DDT emulsion before placing the females, or else were not treated as controls. Counts of the populations were done after 2 weeks. Data are shown in table XXXIII. In both of the crowding conditions the averages of the numbers of eggs, the motile stages and the total populations were less in the DDT treatment than in the control. Analysis of variance showed that the differences in those numbers between the control and the DDT treatment as averages of the crowding conditions were significant at the 1% level of probability. There was no significant interaction between DDT treatment and crowding.

The adverse effect of crowding of the mites on their biotic potential was verified by the results of that experiment. The average of the total populations produced by 5 females in the control and the DDT treatment was 1453.7 while the average of 30 females was 2992.2. In other

words the colonies which started with 5 females multiplied 290.7 times while those starting with 30 females multiplied 99.7 times only.

To summarize the results on the effect of DDT on mite population it was found that:

1. DDT whether in the emulsion form or the wettable powder formulation did not cause any increase in T. telarius or T. cinnabarinus populations raised for 1 to 3 generations.
2. On the contrary, higher concentrations of both formulations resulted in a decrease rather than an increase in reproduction in comparison to untreated mites.
3. Higher concentrations of DDT might cause greater dispersion, but meanwhile, due to the harmful effect they ended in lower populations than were attained in the control.

SUMMARY AND CONCLUSION

Some authors attributed the increase in spider mite populations following the use of DDT to a direct effect on the females, causing them, or their daughters, to lay more eggs than usual. Others claimed that irritation of the mites by DDT causes them to disperse and through dispersion a higher reproductive potential is achieved.

The results of this work showed that it was not possible in any case to produce any increase in egg-laying by DDT treatments. Rearing the mites on treated leaves up to 15 generations did not result in any increase in the egg-laying rate. Moreover, DDT, especially in emulsion, was harmful to the early stages and caused a delay in reaching the adult stage. Mites reared under crowded conditions reproduced at a lower rate than those which were not crowded. But it was found that wider dispersion of the mites under the effect of DDT was not apparent except when higher concentrations were used, which due to the harmful effect on the mites, resulted in lower populations than were attained in the control.

It is concluded that the harmful effect of DDT on the natural enemies of the mites is the major cause of mite outbreaks. The destructive effect of DDT on natural

enemies was proved by many workers. Authors who have claimed build-up of mite populations not explainable by the effect of DDT on natural enemies might have overlooked the presence of predaceous mites and their effective role against spider mites.

Crowding of mite populations was found to be a direct cause of dispersion. Dispersion of the mites and thus more favorable conditions for success in survival might be an indirect effect of DDT, which through its destruction of the natural enemies permits higher populations to survive. More dispersion thus follows because of greater crowding.

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APPENDIX

TABLE XXXIII

Effect of two concentrations of emulsifiable DDT on egg-laying by
T. telarius (L.) females isolated on treated detached leaves*

Female no.	DDT 0.01%			DDT 0.03%			Control		
	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female
1	186	26	7.2	170	33	5.2	138	16	8.6
2	189	27	7.0	150	24	6.3	201	25	8.0
3	203	31	6.5	126	33	3.8	88	20	4.4
4	156	20	7.8	195	20	9.8	184	32	5.8
5	102	22	4.6	149	25	6.0	115	23	5.0
6	187	27	6.9	145	28	5.2	151	16	9.4
7	144	17	8.5	179	16	11.2	87	17	5.1
8	206	33	6.2	174	31	5.6	155	27	5.7
9	167	13	12.8	149	15	9.9	112	16	7.0
10	159	16	9.9	225	16	14.1	250	31	8.1
11	175	25	7.0	161	27	6.0	136	23	5.9
12	190	29	6.6	-	-	-	160	21	7.6
13	203	21	9.7	-	-	-	213	29	7.3
14	144	23	6.3	-	-	-	180	18	10.0
15	83	9	9.2	-	-	-	-	-	-
16	191	26	7.3	-	-	-	-	-	-

*Averages shown in table I.

TABLE XXXIV

Effect of two concentrations of emulsifiable DDT on egg-laying by T. telarius (L.) females when kept in groups on treated detached leaves*

Rep. no.	No. of mites	DDT 0.01%			DDT 0.03%			Control		
		Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female
1	10	156.1	22.7	6.9	145.6	26.3	5.5	134.4	22.7	6.3
2	10	114.8	21.0	6.8	152.2	23.5	6.5	146.8	23.4	6.3
3	10	159.6	22.4	7.1	149.1	19.2	7.8	173.7	19.9	8.7
4	10	137.7	17.3	8.0	152.0	18.6	8.2	179.9	21.5	8.4

*Averages shown in table II.

TABLE XXXV

Effect of one concentration of emulsifiable DDT on egg-laying by isolated T. telarius (L.) females when kept under 67 F. and 14 hours daily photoperiod

(a) Mothers*

Female no.	DDT 0.01%			Control		
	Eggs/ female	Days life span	Eggs/day/ female	Eggs/ female	Days life span	Eggs/day/ female
1	47	17	2.8	125	40	3.1
2	85	33	2.6	129	27	4.8
3	117	30	3.9	55	17	3.2
4	104	34	3.1	78	20	3.9
5	77	26	3.0	154	47	3.2
6	123	26	4.7	50	17	2.9
7	73	23	3.2	105	47	2.2
8	122	37	3.3	109	43	2.5
9	70	23	3.0	73	27	2.7
10	51	17	3.0	79	27	2.9
11	-	-	-	77	23	3.3

* Averages shown in table III.

TABLE XXXV (Continued)

Effect of one concentration of emulsifiable DDT on egg-laying by isolated T. telarius (L.) females when kept under 67 F. and 14 hours daily photoperiod

(b) First generation*

Female no.	DDT 0.01%			Control		
	Eggs/ female	Days life span	Eggs/day/ female	Eggs/ female	Days life span	Eggs/day/ female
1	61	17	3.6	47	12	3.0
2	127	29	4.4	131	39	3.4
3	40	13	3.1	122	34	3.6
4	124	29	4.3	98	35	2.8
5	37	13	2.8	104	26	4.0
6	101	30	3.4	126	29	4.3
7	111	27	4.1	108	31	3.5
8	114	26	4.4	129	28	4.6
9	34	19	1.8	93	26	3.6

* Averages shown in table III.

TABLE XXXVI

Effect of two concentrations of DDT wettable powder on egg-laying by T. telarius (L.) females when treated and placed on treated detached leaves and kept under high humidity conditions

(a) Mothers*

Female no.	DDT 0.05%			DDT 0.1%			Control		
	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female
1	51	12	4.3	104	15	6.9	54	11	4.9
2	64	12	5.3	91	15	6.1	145	15	9.7
3	100	15	6.7	85	15	5.7	149	17	8.8
4	112	15	7.5	100	15	6.7	38	12	3.2
5	57	12	4.8	124	15	8.3	124	12	10.3
6	115	15	7.7	114	15	7.6	58	12	4.8
7	103	15	6.9	89	15	5.9	38	11	3.5
8	130	15	8.7	93	15	6.2	93	12	7.8
9	-	-	-	72	11	6.5	83	11	7.5
10	-	-	-	-	-	-	67	12	5.6
11	-	-	-	-	-	-	92	12	7.7

*Averages shown in table IV.

TABLE XXXVI (Continued)

Effect of two concentrations of DDT wettable powder on egg-laying by T. telarius (L.) females when treated and placed on treated detached leaves and kept under high humidity conditions

(b) First generation*

Female no.	DDT 0.1%			Control		
	Eggs/ female	Days life span	Eggs/day/ female	Eggs/ female	Days life span	Eggs/day/ female
1	51	9	5.7	58	10	5.8
2	28	10	2.8	32	10	3.2
3	38	10	3.8	46	13	3.5
4	56	9	6.2	32	13	2.5
5	39	12	3.3	38	9	4.2
6	45	10	4.5	20	9	2.2
7	41	12	3.4	23	10	2.3
8	29	13	2.2	45	11	4.1
9	47	9	5.2	28	10	2.8
10	51	10	5.1	28	12	2.3
11	21	10	2.1	40	9	4.4
12	-	-	-	39	13	3.0

*Averages shown in table IV.

TABLE XXXVII

Effect of two concentrations of emulsifiable DDT on egg-laying of various generations of T. telarius (L.) females reared continuously on treated detached leaves

(a) First generation*

Female no.	DDT 0.05%			DDT 0.1%			Control		
	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female
1	154	18	8.6	204	23	8.9	175	19	9.2
2	122	12	10.1	184	18	10.2	177	18	9.9
3	144	12	12.0	179	22	8.1	163	15	10.9
4	160	19	8.4	109	12	9.1	168	12	14.0
5	213	18	11.8	149	21	7.1	153	17	9.0
6	176	18	9.8	113	8	14.1	185	20	9.3
7	108	8	13.5	199	15	13.3	206	20	10.3
8	116	23	5.0	157	20	7.9	171	20	8.6
9	225	24	9.4	93	12	7.8	109	9	12.1
10	208	14	14.9	-	-	-	120	15	8.0
11	66	5	13.2	-	-	-	-	-	-
12	184	24	7.7	-	-	-	-	-	-

*Averages shown in table V.

TABLE XXXVII (Continued)

Effect of two concentrations of emulsifiable DDT on egg-laying of various generations of T. telarius (L.) females reared continuously on treated detached leaves

(b) Fourth generation*

Female no.	DDT 0.05%			DDT 0.1%			Control		
	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female
1	181	16	11.3	170	15	11.3	127	24	5.3
2	208	27	7.7	140	16	8.8	233	29	8.0
3	202	27	7.5	81	8	10.1	215	25	8.6
4	160	15	10.7	163	23	7.1	168	24	7.0
5	103	8	12.9	229	26	8.8	174	23	7.6
6	196	26	7.5	149	15	9.9	178	23	7.7
7	93	5	18.6	189	14	13.5	55	5	11.0
8	183	10	18.3	126	10	12.6	-	-	-

*Averages shown in table V.

TABLE XXXVII (Continued)

Effect of two concentrations of emulsifiable DDT on egg-laying of various generations of T. telarius (L.) females reared continuously on treated detached leaves

(c) Tenth generation

Female no.	DDT 0.05%			DDT 0.1%			Control		
	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female
1	100	8	12.5	87	7	12.4	153	21	7.3
2	153	16	9.6	51	11	4.6	197	25	7.9
3	51	8	6.4	147	15	9.8	52	3	17.3
4	203	23	8.8	71	11	6.5	183	24	7.6
5	207	23	9.0	153	12	12.8	174	19	9.2
6	84	11	7.6	48	12	4.0	145	16	9.1
7	94	11	8.6	198	17	11.6	115	8	14.4
8	157	18	8.7	100	8	12.5	103	12	8.6
9	75	8	9.4	95	9	10.6	138	16	8.6

* Averages shown in table V.

TABLE XXXVIII

Effect of two concentrations of emulsifiable DDT on egg-laying of various generations of T. cinnabarinus (Bois.) females reared continuously on treated detached leaves

(a) First generation*

Female no.	DDT 0.05%			DDT 0.1%			Control		
	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female
1	45	14	3.2	98	9	10.9	131	9	14.6
2	81	8	10.1	130	10	13.0	48	10	4.8
3	166	14	11.9	145	13	11.2	87	7	12.4
4	123	11	11.2	81	4	20.3	120	6	20.0
5	136	14	9.7	103	8	12.8	131	10	13.1
6	110	11	10.0	97	15	6.5	67	5	13.4
7	73	4	18.3	62	13	4.8	43	6	7.2
8	118	18	6.6	161	22	7.3	73	13	5.6
9	146	19	7.7	94	15	6.3	214	27	7.9
10	203	27	7.6	101	12	8.4	106	16	6.6
11	188	28	6.7	-	-	-	189	24	7.9
12	175	28	6.3	-	-	-	164	15	10.9
13	-	-	-	-	-	-	191	22	8.7

*Averages shown in table VI.

TABLE XXXVIII (Continued)

Effect of two concentrations of emulsifiable DDT on egg-laying of various generations of T. cinnabarinus (Bois.) females reared continuously on treated detached leaves

(b) Fifteenth generation*

Female no.	DDT 0.05%			DDT 0.1%			Control		
	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female
1	144	15	9.6	130	12	10.8	103	18	5.7
2	92	6	15.3	116	11	10.5	151	12	12.6
3	200	25	8.0	166	16	10.4	124	15	8.3
4	147	19	7.7	147	16	9.2	89	11	8.1
5	185	18	10.3	163	15	10.9	85	11	7.7
6	176	17	10.4	209	19	11.0	176	16	11.0
7	99	11	9.0	89	12	7.4	81	11	7.4
8	105	18	5.8	205	18	11.4	132	17	7.8
9	183	19	9.6	164	16	10.3	225	25	9.0

*Averages shown in table VI.

TABLE XXXIX

Effect of 3 concentrations of emulsifiable DDT on T. telarius (L.) females when placed in groups on treated detached leaves

(a) Egg-laying and longevity*

Rep. no.	No. of mites	DDT 0.05%			DDT 0.1%			DDT 0.2%		
		Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female	Eggs/ female	Days life span	Eggs/ day/ female
1	10	134.7	12.6	10.0	128.4	13.9	9.2	92.6	10.1	8.7
2	10	51.4	7.0	7.8	108.2	12.1	9.2	116.2	12.3	8.5
3	10	106.5	11.4	10.0	104.6	11.0	9.3	88.6	9.9	8.9
4	10	156.4	14.6	10.8	157.1	16.4	9.8	163.6	15.9	10.4
		Control (grouped)			Control (isolated)					
1	10	152.6	14.8	10.6	154.2	14.2	11.1			
2	10	125.6	14.3	9.2	131.0	12.9	10.8			
3	10	96.0	12.0	7.8	81.6	7.6	10.4			
4	10	154.9	15.3	11.0	132.4	13.4	10.1			

* Averages shown in table VII (a).

TABLE XXXIX (Continued)

Effect of 3 concentrations of emulsifiable DDT on T. telarius (L.) females when placed in groups on treated detached leaves

(b) Egg-laying in periods of 3 days*

		Eggs/day/female									
		DDT 0.05%					DDT 0.1%				
Rep. no.	No. of mites	1st per.**	2nd per.	3rd per.	4th per.	5th per.	1st per.	2nd per.	3rd per.	4th per.	5th per.
1	10	8.3	16.9	11.5	9.2	3.9	8.5	12.8	10.6	9.7	5.6
2	10	6.3	8.1	6.1	10.8	0.0	7.3	12.8	10.5	10.6	4.6
3	10	7.2	9.8	12.1	13.7	7.2	7.9	13.3	9.4	9.7	6.3
4	10	8.8	14.5	14.7	7.7	8.3	8.6	13.6	12.0	7.4	7.5
		DDT 0.2%									
1	10	7.8	10.9	10.4	8.3	6.0					
2	10	8.5	14.2	11.8	3.9	3.9					
3	10	7.1	11.8	8.0	8.6	8.8					
4	10	9.1	13.7	12.6	7.9	8.6					

*Averages shown in table VII (b).

**Per. = Period.

TABLE XXXIX (Continued)

Effect of 3 concentrations of emulsifiable DDT on T. telarius (L.)
females when placed in groups on treated detached leaves

(b) Egg-laying in periods of 3 days (Continued)*

Rep. no.	No. of mites	Eggs/day/female									
		Control collective					Control separate				
		1st per.	2nd per.	3rd per.	4th per.	5th per.	1st per.	2nd per.	3rd per.	4th per.	5th per.
1	10	10.1	15.6	11.8	9.6	6.1	9.1	16.2	13.2	10.2	6.6
2	10	8.1	13.6	9.1	10.1	5.3	7.8	14.4	12.8	12.3	6.8
3	10	10.2	10.0	9.7	7.5	1.8	8.6	16.4	12.1	9.6	5.3
4	10	12.0	16.0	13.7	7.9	5.6	10.6	13.9	12.0	6.8	7.2

*
Averages shown in table VII (b).

TABLE XL

Effect of 3 generations of emulsifiable DDT on progeny of T. telarius (L.) when kept on treated detached leaves*

Replication no.	DDT 0.05%			DDT 0.1%		
	% dead eggs & larvae	% entangled larvae & nymphs	% reaching adult stage in 7 days	% dead eggs & larvae	% entangled larvae & nymphs	% reaching adult stage in 7 days
1	9.1	24.1	3.2	12.6	30.8	3.7
2	5.6	4.1	3.3	6.6	15.2	4.8
3	9.0	21.9	12.1	11.0	38.2	7.6
4	11.6	20.5	3.0	14.2	23.6	3.7
	DDT 0.2%			Control		
	% dead eggs & larvae	% entangled larvae & nymphs	% reaching adult stage in 7 days	% dead eggs & larvae	% entangled larvae & nymphs	% reaching adult stage in 7 days
1	30.1	50.6	1.3	1.3	5.1	19.3
2	11.6	36.7	2.0	1.5	3.3	19.0
3	25.3	54.6	6.0	1.8	4.8	35.5
4	14.6	45.1	1.4	7.3	4.6	10.6

* Averages shown in table VIII.

TABLE XLI

Effect of 2 concentrations of DDT wettable powder on progeny of T. telarius (L.) kept on treated detached leaves. Mothers were treated and kept on treated detached leaves for 4 days and then removed

(a) Dead and entangled mites*

Replication no.	DDT 0.05%			DDT 0.1%		
	Total pop.**	% dead egg & larvae	% entangled larvae & nymphs	Total pop.	% dead egg & larvae	% entangled larvae & nymphs
1	234	2.1	7.7	268	6.6	6.3
2	394	3.6	26.6	386	4.9	35.2
3	170	21.2	1.7	246	8.5	2.8
4	251	10.6	2.8	414	8.0	17.5
Control						
1	274	5.8	3.3			
2	387	5.4	22.2			
3	200	14.0	3.5			
4	302	7.0	21.2			

*Averages shown in table IX (a).

**Total pop. = total population.

TABLE XLI (Continued)

Effect of 2 concentrations of DDT wettable powder on progeny of T. telarius (L.) kept on treated detached leaves. Mothers were treated and kept on treated detached leaves for 4 days and then removed

(b) Percentages of mites reaching adult female stage in days indicated*

Days	% reaching adult female stage							
	DDT 0.05%				DDT 0.1%			
	1st rep.	2nd rep.	3rd rep.	4th rep.	1st rep.	2nd rep.	3rd rep.	4th rep.
9	0.0	5.8	0.0	16.8	0.0	4.6	0.7	22.0
10	7.8	29.2	40.7	51.5	20.8	22.2	31.0	51.2
11	52.6	68.2	93.0	69.5	56.0	51.2	66.3	70.3
12	87.1	83.1	100.0	98.2	80.5	77.2	97.2	92.8
13	97.4	89.6	-	99.4	98.7	81.8	98.6	98.7
14	98.3	98.7	-	100.0	100.0	96.3	100.0	99.1
15	100.0	100.0	-	-	-	100.0	-	100.0
Control								
9	0.0	11.7	0.9	17.3				
10	35.6	36.7	42.6	44.9				
11	79.9	55.0	96.5	57.7				
12	97.3	76.7	98.2	82.7				
13	99.3	87.3	99.1	89.1				
14	100.0	99.5	100.0	98.7				
15	-	100.0	-	100.0				

*Averages shown in table IX (b).

TABLE XLI (Continued)

Effect of 2 concentrations of DDT wettable powder on progeny of T. telarius (L.) kept on treated detached leaves. Mothers were treated and kept on treated detached leaves for 4 days and then removed

(c) Percentages of mites reaching adult male stage in days indicated*

Days	% reaching adult male stage							
	DDT 0.05%				DDT 0.01%			
	1st rep.	2nd rep.	3rd rep.	4th rep.	1st rep.	2nd rep.	3rd rep.	4th rep.
9	1.1	12.4	15.6	24.0	16.4	17.0	17.7	27.2
10	55.8	37.2	68.9	44.0	63.0	38.0	74.7	57.0
11	82.1	70.2	97.8	72.0	91.8	67.0	92.4	83.3
12	97.9	88.4	100.0	98.0	97.3	82.0	98.7	95.6
13	100.0	95.0	-	98.0	100.0	88.0	100.0	100.0
14	-	100.0	-	98.0	-	96.0	-	-
15	-	-	-	100.0	-	100.0	-	-
Control								
9	16.0	16.0	40.0	16.4				
10	56.0	44.0	82.0	41.0				
11	87.0	64.0	100.0	65.6				
12	98.0	88.0	-	88.6				
13	100.0	91.0	-	98.4				
14	-	98.0	-	100.0				
15	-	100.0	-	-				

*Averages shown in table IX (c).

TABLE XLII

Effect of DDT on progeny of T. cinnabarinus (Bois.) kept on treated detached leaves. Mothers were kept on treated detached leaves for 4 days and then removed

Dead and entangled mites*

Replication no.	DDT 0.05% E.C.			DDT 0.1% E.C.		
	Total pop.	% dead eggs & larvae	% entangled larvae & nymphs	Total pop.	% dead eggs & larvae	% entangled larvae & nymphs
1	567	19.4	72.0	233	50.2	49.8
2	588	22.6	54.0	640	16.3	65.6
3	591	21.0	63.5	656	26.5	65.4
4	474	31.4	59.1	752	20.2	60.0
	DDT 0.2% W.P.			Control		
	Total pop.	% dead eggs & larvae	% entangled larvae & nymphs	Total pop.	% dead eggs & larvae	% entangled larvae & nymphs
1	546	7.7	54.6	630	5.6	25.6
2	550	5.8	52.2	618	12.1	26.1
3	609	11.0	55.8	706	6.5	34.0
4	841	28.8	43.3	585	5.0	16.9

* Averages shown in table X.

TABLE XLIII

Effect of DDT on progeny of T. cinnabarinus (B ois.) kept on treated detached leaves. Mothers were kept on treated detached leaves for 24 hours and then removed

(a) Percentages of mites reaching adult female stage in days indicated*

Days	% reaching adult female stage					
	DDT 0.05% E.C.			DDT 0.1% E.C.		
	1st rep.	2nd rep.	3rd rep.	1st rep.	2nd rep.	3rd rep.
6	0.0	0.0	0.0	0.0	0.0	0.0
7	7.1	30.2	5.2	0.0	20.5	0.0
8	92.9	46.5	86.8	100.0	46.2	76.2
9	0.0	22.1	8.0	0.0	30.8	21.9
10	0.0	1.2	0.0	0.0	2.5	1.9
	DDT 0.2% W.P.			Control		
	1st rep.	2nd rep.	3rd rep.	1st rep.	2nd rep.	3rd rep.
6	0.0	0.0	0.0	0.0	0.0	14.7
7	21.0	57.2	17.2	69.1	53.4	28.6
8	79.0	32.9	59.1	30.9	26.1	53.4
9	0.0	9.4	20.7	0.0	20.1	2.9
10	0.0	0.5	3.0	0.0	0.4	0.4

*Averages shown in table XI (a).

TABLE XLIII (Continued)

Effect of DDT on progeny of T. cinnabarinus (Bois.) kept on treated detached leaves. Mothers were kept on treated detached leaves for 24 hours and then removed

(b) Percentages of mites reaching adult male stage in days indicated*

Days	% reaching adult male stage					
	DDT 0.05% E.C.			DDT 0.1% E.C.		
	1st rep.	2nd rep.	3rd rep.	1st rep.	2nd rep.	3rd rep.
6	0.0	0.0	6.4	0.0	0.0	5.1
7	66.7	89.7	61.7	80.0	84.6	25.7
8	33.3	7.7	31.9	20.0	11.5	69.2
9	0.0	2.6	0.0	0.0	3.9	0.0
Days	DDT 0.2% W.P.			Control		
	1st rep.	2nd rep.	3rd rep.	1st rep.	2nd rep.	3rd rep.
6	0.0	2.7	25.0	11.8	6.9	29.7
7	100.0	88.5	36.3	88.2	91.4	53.1
8	0.0	10.8	38.7	0.0	0.0	17.2
9	0.0	0.0	0.0	0.0	1.7	0.0

*Averages shown in table XI (b).

TABLE XLIV

Effect of DDT on eggs of T. cinnabarinus (Bois.) treated 24 hours
from the beginning of egg-laying*

Rep. no.	DDT 0.05% E.C.			DDT 0.1% W.P.		
	Total no. of eggs	No. of dead eggs	% dead eggs	Total no. of eggs	No. of dead eggs	% dead eggs
1	210	29	13.8	180	39	20.7
2	167	38	22.8	241	44	18.3
3	170	60	35.3	164	22	14.3
4	115	43	37.4	73	18	24.7
	DDT 0.2% W.P.			Control		
	Total no. of eggs	No. of dead eggs	% dead eggs	Total no. of eggs	No. of dead eggs	% dead eggs
1	184	27	14.7	167	4	2.4
2	241	20	8.3	194	11	5.7
3	91	38	41.8	102	4	3.9
4	73	22	30.1	50	0	0.0

* Averages shown in table XII.

TABLE XLV

Effect of DDT on eggs and larvae of T. cinnabarinus (Bois.) treated
72 hours from the beginning of egg-laying*

Rep. no.	DDT 0.05% E.C.					DDT 0.1% W.P.				
	Total pop.	No. of dead eggs	% dead eggs	No. of dead larvae	% dead larvae	Total pop.	No. of dead eggs	% dead eggs	No. of dead larvae	% dead larvae
1	127	86	67.7	25	19.7	132	22	16.7	17	12.9
2	111	73	65.8	21	18.9	73	11	15.1	9	12.3
3	148	65	43.9	23	15.5	185	17	9.2	8	4.3
4	96	49	51.0	23	24.0	122	7	5.7	5	4.1
	DDT 0.2% W.P.					Control				
	Total pop.	No. of dead eggs	% dead eggs	No. of dead larvae	% dead larvae	Total pop.	No. of dead eggs	% dead eggs	No. of dead larvae	% dead larvae
1	104	57	54.8	8	7.7	146	13	8.9	0	0.0
2	110	46	41.8	16	14.5	170	2	1.2	2	1.2
3	159	25	15.7	7	4.4	148	10	6.8	3	2.0
4	105	16	15.2	2	1.9	156	7	4.5	0	0.0

*Averages shown in table XIII.

TABLE XLVI

Effect of crowding of T. telarius (L.) females on egg-laying and on life span*

Rep. no.	Number of females/disc (1 inch diameter)					
	3 females		10 females		20 females	
	Eggs/day/ female	Days life span	Eggs/day/ female	Days life span	Eggs/day/ female	Days life span
1	8.0	11.3	7.7	8.6	7.4	7.4
2	8.3	13.3	8.2	9.2	6.1	8.8
3	6.7	10.7	5.9	5.6	4.6	5.6
4	6.7	10.3	6.7	6.9	4.7	7.2
5	10.3	14.0	6.7	9.3	5.9	8.3
	25 females		30 females			
	Eggs/day/ female	Days life span	Eggs/day/ female	Days life span		
	Eggs/day/ female	Days life span	Eggs/day/ female	Days life span		
1	6.3	7.1	6.3	6.6		
2	6.2	8.5	4.6	8.9		
3	5.7	6.8	4.0	6.8		
4	4.3	7.0	3.9	7.5		
5	5.9	5.9	5.0	5.0		

*Averages shown in table XIV.

TABLE XLVII

Effect of DDT on dispersion of T. telarius (L.) colonies from an infested leaf to lower and upper uninfested discs

Percentages of dispersed mites*

Rep. no.	DDT 0.01% E.C.				DDT 0.03% E.C.			
	Total motile stages	% moved to			Total motile stages	% moved to		
		Lower discs	1st upper discs	Highest discs		Lower discs	1st upper discs	Highest discs
1	266	12.4	30.8	17.3	174	6.3	25.3	4.6
2	180	12.2	13.9	7.8	111	5.4	0.9	7.2
3	347	6.6	25.9	23.6	158	1.9	11.4	13.3
Rep. no.	DDT 0.15% W.P.				Control			
	Total motile stages	% moved to			Total motile stages	% moved to		
		Lower discs	1st upper discs	Highest discs		Lower discs	1st upper discs	Highest discs
1	236	3.0	16.9	21.2	366	9.0	11.5	24.6
2	192	3.6	5.7	9.9	366	18.0	15.3	11.7
3	246	1.2	14.6	19.5	199	2.5	24.6	6.0

*Averages shown in table XXII (a).

TABLE XLVIII

Effect of light on upward and downward dispersion of T. telarius
(L.) in presence and absence of DDT*

Fourteen hours daily illumination						
Rep. no.	DDT 0.01%			Control		
	Total pop.	% moved to upper discs	% moved to lower discs	Total pop.	% moved to upper discs	% moved to lower discs
1	359	76.6	0.8	411	54.0	0.0
2	342	38.9	2.3	278	72.0	1.4
3	188	27.1	2.1	208	70.8	2.1
Continuous						
1	170	17.6	6.0	275	36.0	0.0
2	162	35.2	2.5	294	5.8	1.3
3	103	54.3	14.6	103	52.5	15.5

*Averages shown in table XXIII.

TABLE XLIX

Effect of emulsifiable DDT on dispersion of T. telarius (L.) from plant to plant when attached to each other

(a) Counts of mites 4 days after spraying*

Rep. no.	DDT 0.01%				DDT 0.03%			
	Total pop.	% adult stages	% larvae & nymphs	% dead eggs & larvae	Total pop.	% adult stages	% larvae & nymphs	% dead eggs & larvae
1	341	1.5	85.9	12.6	279	4.7	68.8	26.5
2	309	4.2	73.5	22.3	308	2.9	68.5	28.6
3	420	7.4	77.4	15.2	288	8.3	66.4	25.3
4	484	27.3	60.9	11.8	443	21.9	56.9	21.2
	DDT 0.05%				Control			
	Total pop.	% adult stages	% larvae & nymphs	% dead eggs & larvae	Total pop.	% adult stages	% larvae & nymphs	% dead eggs & larvae
1	342	1.5	60.2	38.3	297	2.7	91.9	5.4
2	337	3.0	71.1	25.9	370	14.1	81.6	4.3
3	273	9.5	55.0	35.5	403	19.4	75.1	5.5
4	364	21.7	37.9	40.4	459	33.1	55.8	11.1

*Averages shown in table XXIV (a).

TABLE XLIX (Continued)

Effect of emulsifiable DDT on dispersion of T. telarius (L.) from plant to plant when attached to each other

(b) Dispersion of mites 4 days after spraying*

DDT 0.01%									
Rep. no.	Total live motile stages	% of motile stages moved to							
		1st leaf		2nd leaf		3rd leaf		4th leaf	
		Upper surface	Lower surface	Upper surface	Lower surface	Upper surface	Lower surface	Upper surface	Lower surface
1	297	11.1	20.2	3.3	2.4	0.0	0.0	0.0	0.0
2	262	1.5	31.3	1.9	1.9	0.0	0.0	0.0	0.0
3	356	0.3	59.6	1.7	10.1	0.0	2.2	0.0	0.0
4	427	6.3	61.4	2.6	0.0	0.0	0.2	0.0	0.0
DDT 0.03%									
1	205	8.4	28.5	7.5	5.1	0.0	0.0	0.0	0.0
2	220	0.5	29.1	0.0	0.0	0.0	0.0	0.0	0.0
3	215	10.2	53.0	0.9	5.6	0.0	0.0	0.0	0.0
4	349	12.3	40.4	4.3	2.6	0.0	0.0	0.0	0.0

*Averages shown in table XXIV (b).

TABLE XLIX (Continued)

Effect of emulsifiable DDT on dispersion of T. telarius (L.) from plant to plant when attached to each other

(b) Dispersion of mites 4 days after spraying (Continued)*

DDT 0.05%									
% of motile stages moved to									
Rep. no.	Total live motile stages	1st leaf		2nd leaf		3rd leaf		4th leaf	
		Upper surface	Lower surface	Upper surface	Lower surface	Upper surface	Lower surface	Upper surface	Lower surface
1	211	0.0	42.2	11.4	18.0	0.0	0.9	0.5	0.0
2	229	2.2	38.9	1.8	5.3	0.4	0.4	0.0	0.0
3	176	9.1	79.5	1.1	2.8	0.0	1.1	0.0	0.0
4	217	6.9	66.8	2.8	1.4	0.0	0.5	0.0	0.0
Control									
1	281	0.7	52.7	3.2	0.0	0.0	0.0	0.0	0.0
2	354	1.1	8.8	3.1	0.0	0.0	0.0	0.0	0.0
3	381	15.0	18.4	1.0	0.0	0.0	0.0	0.0	0.0
4	408	5.9	46.8	0.0	0.7	0.0	0.0	0.0	0.0

*Averages shown in table XXIV (b).

TABLE L

Effect of DDT wettable powder on dispersion of T. telarius (L.) from plant to plant when attached to each other

(a) Counts of mites 4 days after spraying*

Rep. no.	DDT 0.05%				DDT 0.1%			
	Total pop.	% adult stages	% larvae & nymphs	% dead eggs & larvae	Total pop.	% adult stages	% larvae & nymphs	% dead eggs & larvae
1	899	21.0	64.0	15.0	796	28.1	54.8	17.1
2	967	23.0	70.7	6.3	756	20.0	68.0	12.0
3	1004	15.4	63.5	21.1	924	14.4	67.6	18.0
Control								
1	706	20.8	70.0	9.2				
2	1009	25.3	64.6	10.1				
3	744	13.2	65.3	21.5				

*Averages shown in table XXV (a).

TABLE L (Continued)

Effect of DDT wettable powder on dispersion of T. telarius (L.)
from plant to plant when attached to each other

(b) Dispersion of mites 4 days after spraying*

DDT 0.05%						DDT 0.1%				
% moved to						% moved to				
Rep. no.	Total live motile stages	1st leaf	2nd leaf	3rd leaf	4th leaf	Total live motile stages	1st leaf	2nd leaf	3rd leaf	4th leaf
1	764	45.6	12.1	2.2	0.4	660	64.7	10.9	0.6	0.0
2	906	69.4	1.5	0.0	0.0	665	59.0	10.5	0.3	0.0
3	792	90.8	2.1	0.0	0.0	758	84.4	1.8	0.0	0.0
Control										
1	641	71.9	9.2	0.2	0.0					
2	907	44.1	0.7	0.0	0.0					
3	584	78.6	0.0	0.0	0.0					

*Averages shown in table XXV (b).

TABLE LI

Effect of DDT wettable powder on dispersion of T. cinnabarinus
(Bois.) from plant to plant under different crowding conditions

(a) Disperion of a colony formed by 5 females*

DDT 0.2% W.P.							
% of motile stages moved to							
Rep. no.	Total live motile stages	1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	6th leaf
1	139	48.9	2.9	2.9	0.7	0.0	0.0
2	130	66.2	0.0	0.1	0.0	0.0	0.0
3	53	28.3	0.0	3.8	0.0	0.0	1.9
Control							
1	223	54.3	9.0	0.0	0.0	0.0	0.0
2	222	46.8	21.2	2.3	0.0	0.0	0.0
3	288	33.3	1.0	1.4	0.0	0.0	0.0

*Averages shown in table XXVI (a).

TABLE LI (Continued)

Effect of DDT wettable powder on dispersion of T. cinnabarinus
(Bois.) from plant to plant under different crowding conditions

(b) Dispersion of a colony formed by 10 females*

DDT 0.2% W.P.							
% of motile stages moved to							
Rep. no.	Total live motile stages	1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	6th leaf
1	255	40.4	25.1	2.0	0.0	0.0	0.0
2	194	54.6	9.8	0.0	0.5	0.0	0.0
3	221	62.4	2.7	3.2	0.0	0.0	0.0
Control							
1	432	17.4	23.4	30.8	2.3	0.0	0.0
2	357	33.9	30.3	6.2	0.0	0.0	0.0
3	472	29.9	45.6	1.7	0.0	0.0	0.0

*Averages shown in table XXVI (a).

TABLE LI (Continued)

Effect of DDT wettable powder on dispersion of T. cinnabarinus
(Bois.) from plant to plant under different crowding conditions

(c) Dispersion of a colony formed by 20 females*

DDT 0.2% W.P.							
% of motile stages moved to							
Rep. no.	Total live motile stages	1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	6th leaf
1	301	20.3	25.6	13.6	2.0	0.3	0.3
2	482	17.6	17.6	31.3	0.2	0.0	0.0
3	408	41.9	23.5	6.1	0.5	1.5	0.0
Control							
1	803	24.9	32.4	11.3	0.6	0.0	0.0
2	665	16.8	29.9	32.3	2.4	0.3	0.3
3	793	34.3	34.3	5.5	0.1	0.0	0.0

* Averages shown in table XXVI (a).

TABLE LII

Effect of DDT residue on dispersion of T. telarius (L.) from plant to plant when attached to each other*

DDT 0.05% E.C.									
Rep. no.	Total live motile stages	% of motile stages moved to							
		1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	6th leaf	7th leaf	8th leaf
1	437	38.9	32.1	17.7	6.0	1.9	0.8	1.6	1.0
2	350	22.3	29.1	16.0	11.1	6.7	8.3	3.1	3.4
3	794	57.2	28.0	12.1	2.0	0.1	0.1	0.4	0.1
DDT 0.1% E.C.									
1	217	44.2	30.0	6.0	6.9	7.4	3.7	3.7	0.9
2	430	46.3	31.9	11.6	5.1	1.9	0.9	0.7	1.6
3	684	27.6	25.0	34.9	3.7	2.0	4.7	2.0	0.1

*Averages shown in table XXVII.

TABLE LII (Continued)

Effect of DDT residue on dispersion of T. telarius (L.) from plant to plant when attached to each other (Continued)*

DDT 0.2% W.P.									
Rep. no.	Total live motile stages	% of motile stages moved to							
		1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf	6th leaf	7th leaf	8th leaf
1	180	35.6	35.6	13.9	8.3	1.7	4.3	0.6	0.0
2	290	12.1	23.1	45.9	11.4	1.7	3.1	2.7	0.0
3	808	39.5	44.7	11.8	0.7	1.5	0.6	0.5	0.7
Control									
1	368	38.9	32.1	17.7	6.0	1.9	0.8	1.6	1.0
2	422	47.2	26.8	8.8	3.6	2.6	6.4	3.0	1.6
3	893	40.4	38.5	15.7	4.0	0.7	0.2	0.2	0.3

*Averages shown in table XXVII.

TABLE LIII

Effect of emulsifiable DDT on T. telarius (L.) population raised for 2 generations on cut bean plants attached to each other

Populations produced by 10 original females kept for 17 days

Rep. no.	DDT 0.01%			DDT 0.03%		
	No. of eggs	No. of motile stages	Total pop.	No. of eggs	No. of motile stages	Total pop.
1	7619	3191	10810	4165	1894	6059
2	4912	1201	6113	3880	792	4672
3	5592	2928	8520	5024	3129	8153
	DDT 0.05%			Control		
	No. of eggs	No. of motile stages	Total pop.	No. of eggs	No. of motile stages	Total pop.
1	5642	2903	8545	5977	3124	9101
2	2896	384	3280	4704	1360	6064
3	6504	3120	9624	6040	3121	9161

*

Averages shown in table XXVIII.

TABLE LIV

Effect of emulsifiable DDT on T. telarius (L.) population raised for 3 generations on cut bean plants attached to each other

Populations produced by 10 original females kept for 25 days*

Rep. no.	DDT 0.01%			DDT 0.03%		
	No. of eggs	No. of motile stages	Total pop.	No. of eggs	No. of motile stages	Total pop.
1	4024	5192	9216	5496	7786	13282
2	3200	10064	13264	4928	6240	11168
3	2240	6144	8384	2120	2626	4796
	DDT 0.05%			Control		
	No. of eggs	No. of motile stages	Total pop.	No. of eggs	No. of motile stages	Total pop.
1	3680	4384	8064	3987	6600	10587
2	6266	5931	12197	9416	7696	17112
3	1384	2080	3464	2536	3968	6504

*Averages shown in table XXIX.

TABLE LV

Effect of emulsifiable DDT on T. telarius (L.) population raised for one generation on bean plants growing in trays

Populations produced by 20 original females kept for 11 days*

Rep. no.	DDT 0.05%				DDT 0.1%			
	% infested leaves	No. of eggs	No. of motile stages	Total pop.	% infested leaves	No. of eggs	No. of motile stages	Total pop.
1	62.5	4524	5308	9832	62.5	3396	5252	8648
2	33.3	4160	5228	9388	35.4	3816	5212	9028
3	39.6	2124	4888	7012	43.6	2004	3916	5920
	DDT 0.2%				Control			
	% infested leaves	No. of eggs	No. of motile stages	Total pop.	% infested leaves	No. of eggs	No. of motile stages	Total pop.
1	72.9	3512	4944	8456	37.5	3988	5160	9148
2	47.9	1448	3368	4816	31.3	3588	4560	8148
3	50.0	1472	3264	4736	56.3	2256	4512	6768

*Averages shown in table XXX.

TABLE LVI

Effect of DDT on T. cinnabarinus (Bois.) population raised for
2 generations on bean plants growing in trays

Populations produced by 20 original females kept for 17 days*

Rep. no.	DDT 0.05% E.C..			DDT 0.1% E.C.		
	No. of eggs	No. of motile stages	Total pop.	No. of eggs	No. of motile stages	Total pop.
1	12056	11376	23432	9360	5992	15352
2	10563	8672	19240	6440	4704	11144
3	7824	8880	16704	4056	4104	8160
	DDT 0.2% W.P.			Control		
	No. of eggs	No. of motile stages	Total pop.	No. of eggs	No. of motile stages	Total pop.
1	14952	13120	28072	17960	17376	35336
2	15144	12184	27328	12568	15552	28120
3	10704	8768	19472	15248	20112	35360

*Averages shown in table XXXI.

TABLE LVII

Effect of residues of emulsifiable DDT on T. telarius (L.)
population raised under two different crowding conditions

Populations counted after 14 days*

Rep. no.	DDT 0.05%			Control		
	No. of eggs	No. of motile stages	Total pop.	No. of eggs	No. of motile stages	Total pop.
Populations produced by 5 original females						
1	978	874	1852	969	1088	2057
2	229	321	550	1463	1434	2897
3	192	133	325	591	450	1041
Populations produced by 30 original females						
1	1071	2042	3113	2396	2439	4835
2	494	1503	2002	1220	1352	2572
3	1436	865	2301	2185	945	3130

*Averages shown in table XXXII.

AUTOBIOGRAPHY

Hassan H. Attiah was born in Tanta, Egypt, United Arab Republic, October 24, 1919. He received his high school diploma from Tanta High School in June 1935. He entered Cairo University and obtained the degree of Bachelor of Science from the College of Agriculture in June 1939. Since 1942 he has been working for the Crop Protection Department of the Ministry of Agriculture at Dokki, Cairo, Egypt. He began his work as an assistant entomologist and now is head of the Acarology Investigations in the same Department. He entered the United States on January 27, 1959, in a training program. He attended the University of California during the spring of 1959 studying tetranychid mites under Dr. E. A. Pritchard. He visited the Citrus Experiment Station at Riverside, the U. S. Cotton Field Station at Shafter and the United States Department of Agriculture Station at Whitter. During the summer of 1959 he attended the Institute of Acarology, College Park, Maryland. He then visited the University of Florida, Citrus Experiment Station, at Lake Alfred, and the Subtropical Experiment Station at Homestead, as well as the U. S. Department of Agriculture Plant Introduction Garden at Miami. In September 1959, he spent some time with

Dr. E. W. Baker of the U. S. National museum studying taxonomic aspects of different mites. He entered Louisiana State University in 1959, and obtained the degree of Master of Science in January 1961. He continued studies toward the degree of Doctor of Philosophy for which he is now a candidate. He has published several papers in Egypt and in the U. S. A. in the field of Acarology.

EXAMINATION AND THESIS REPORT

Candidate: Hassan H. Attiah

Major Field: Entomology

Title of Thesis: Population Dynamics of Spider Mites Influenced by DDT.

Approved:

H. B. Boudreau
Major Professor and Chairman

Max Goodrich
Dean of the Graduate School

EXAMINING COMMITTEE:

John S. Russell
L. D. Newsome
J. H. Roberts
L. L. Forbes

Date of Examination:

November 27, 1962