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Laboratory study of the relative effectiveness of certain insecticides used against Blattella germanica, Blatta orientalis and Periplaneta fuliginosa.

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LABORATORY STUDY OF THE RELATIVE EFFECTIVENESS OF CERTAIN INSECTICIDES USED AGAINST BLATTELLA GERMANICA, BLATTA ORIENTALIS AND PERIPLANETA FULIGINOSA

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INTRODUCTION

Cockroaches are believed to be tropical in origin and more than 2000 species have been recorded in the world. The fossil remains of this ancient group of insects indicate that they were most abundant in the Carboniferous Age, more than 200 million years ago. At least five species are presently recognized as important household pests. They are the German roach, Blattella germanica (Linnaeus), the oriental roach, Blatta orientalis Linnaeus, the American roach, Periplaneta americana (Linnaeus), the Australian roach, Periplaneta australasiae (Fabricius), and the brown-banded roach, Supella supellectilium (Serville). All of these species originated in the tropics and were introduced into the United States through channels of commerce. Roaches are thermophilic insects, principally distributed in the tropics. They are seldom found in the colder regions and their populations steadily decrease as the distance from the tropics increases.

Roaches often become economically important because of their omnivorous nature. They are destructive to most kinds of plant and animal products and their fetid odor may be imparted to food over which they crawl. Furthermore, they have been incriminated in spreading several human

diseases such as dysentery and typhoid and are also potential carriers of other pathogenic microorganisms.

This study was conducted to test the effectiveness of six insecticides against roaches under laboratory conditions. Three methods were used to treat the roaches, viz. feeding, dipping, and exposure to treated surfaces. The selection of insecticides for the tests was based on insecticides recommended in the U. S. Department of Agriculture Handbook No. 313.

The insecticides used in this study included the chlorinated hydrocarbons DDT (technical 77.2% P, p^1 isomer), chlordane (technical 72%), heptachlor (technical 98%), dieldrin (50% wettable powder) and two organophosphate insecticides malathion (57% emulsifiable concentrate) and Diazinon (25% emulsifiable concentrate). Each insecticide was tested at two concentrations and replicated five times. Tests were conducted against the German roach, Blattella germanica (Linnaeus), the oriental roach, Blatta orientalis Linnaeus, and the smokey-brown roach, Periplaneta fuliginosa (Serville).

LITERATURE REVIEW

Most of the literature reviewed in connection with this study dealt with insecticide resistance in the German roach, Blattella germanica (Linnaeus).

Heal et al (1953) was the first to report resistance to chlordane in the German roach. Since then resistance has become so widespread in this species that it is difficult to locate populations which are susceptible to chlordane.

Lofgren et al (1956) found that 12 out of 28 collections from homes in Florida were moderately to high resistant to chlordane. The LT-50's of the 28 ranged from 3.2 to 126 hours.

Grayson (1961) pointed out that although there is widespread resistance to chlorinated hydrocarbons in the German roach, there are still populations that can be satisfactorily controlled with chlordane.

The Tenth Report of the Expert Committee on insecticides of the World Health Organization (1960) expressed the opinion that resistance to all chlorinated hydrocarbons was generally restricted to the southern United States but widespread in many northern cities, with a few resistant populations in some Canadian cities (Grayson et al, 1960).

Dold (1962) asserted that there was a great difference in susceptibility to chlordane by German roaches collected from 20 locations throughout Indiana. The lethal time (LT-50) ranged from 7.8 to 91 hours.

The advent of resistance to chlorinated hydrocarbons Lofgren et al (1957) led to the use of the organophosphorus compounds, malathion and Diazinon. Only low to moderate resistence to organophosphate insecticides in natural populations of German roaches has been confirmed up to the present time.

However, Grayson (1960) and Burden et al (1959) demonstrated that the German roach can become highly resistant to malathion in several strains among those collected from nine military areas in late 1959 and early 1960.

The first occurrence of resistance to malathion in natural infestations of the German roach was announced by Grayson (1961).

Grayson (1963) showed that resistance to Diazinon develops slowly in the German roach as compared to resistance to malathion. Therefore, the report of Diazinon resistance in field populations was perhaps attributed to the more widespread and intensive use of this material in roach control during the past five or six years.

Resistance to organophosphates has not been shown in other species of roaches, but there has been a report of resistance to DDT and chlordane in large nymphs of the oriental roach in Germany (Webb, 1961).

Mixtures of malathion and dieldrin were found most effective against resistant German, American and oriental roaches (Lemke, 1955).

Gross resistance to dieldrin in chlordane-resistant roaches was reported by Clarke and Cochran (1959). Jarvis and Grayson (1957), and Grayson and Jarvis (1958) showed that chlordane-resistant German roaches could not be controlled with the recommended rate of 0.5% dieldrin.

After dipping, the female roaches from a DDT-resistant strain were found to be 497 times more resistant to DDT, but exhibited only a slight increase in resistance when exposed to chlordane, dieldrin or malathion. Comparatively, a chlordane-resistant strain exhibited a 280-fold resistance to chlordane and a 212-fold resistance to dieldrin (Clarke and Cochran, 1959).

Fish et al (1953) reported that although Diazinon was effective against chlorinated hydrocarbon resistant house flies, but it was not effective against chlorinated hydrocarbon resistant roaches since they are also resistant to Diazinon. However, Diazinon was found more toxic than dieldrin and chlordane against normal strains of roaches.

Grayson (1964) indicated Bayer 39007, MCA-600, and Diazinon as the most effective materials in killing both resistant and non-resistant German roaches after deposits had aged for periods up to 60 days on treated panels. When roaches were exposed to the aged panels mortality was achieved within a relatively short period of time (number of hours not specified).

Ishii et al (1965) found dieldrin, malathion and chlordane highly toxic to the adults of a susceptible strain of the German roach.

Flynn et al (1965) tested residual deposits of Diazinon and Baygon (carbamic acid, methyl-, o-isopropoxyphenyl) against German roaches. Several panels were treated with the insecticides by spray application. After the panels dried for one day the roaches were placed on them and given fresh food (ground laboratory dog chow) and water. The test chamber was arranged in such a manner that the roaches had access to both treated and untreated surfaces. At a deposit of 25 mg/ft^2, Diazinon gave 100% mortality within three days while Baygon under the same conditions killed only 11% in 18 days.

Morrill (1944) fed DDT mixed with food to German roaches and obtained 100% mortality within 21 days. However, during that time the insects reproduced indicating that DDT was not a very effective roach control pesticide.

Fraeborn (1944) found that all roaches except the German roach could be controlled with 5% DDT sprays and 10% DDT dusts. However, several applications of 5% spray or 25% dust gave reasonable control of the German roaches.

Davis (1946) stated that a 10% DDT dust gave effective control of both oriental and American roaches but was less effective against brown-banded and German roaches.

Muma (1946) recommended a 5% DDT spray for roach control but confirmed that the German roach was difficult to kill even though a single application appreciably reduced an infestation.

The city of Bedford, Indiana, experienced a heavy infestation of oriental roaches. Eighteen thousand inhabitants reported roaches invading homes and apartments from outlets in bathtubs, sinks, and lavatories. At night, basements and porches teemed with roaches in such numbers that they actually climbed over each other. Chlordane at 4% concentration was applied with a 60 gal. Quincy compressor at 150 PSI pressure. A total of 260 gal. of insecticides was used for the treatment which required 80 man hours. Observations at 14 and 30 day intervals after treatment revealed successful decreases in oriental invasions of premises Meley (1957).

Lofgren et al (1956) tested several insecticides including malathion, Diazinon and chlordane against natural infestation of German roaches. The sprays were applied as spot treatments to the point of runoff to areas where roaches were hiding or were most likely to walk. The insecticides were evaluated on the basis of percent reduction in the number of live roaches after treatment. Ninety to 100% control was obtained with all treatments. Lofgren et al (1956) further compared residual deposits (aging tests) of malathion, Diazinon and chlordane by spraying several unpainted plywood panels. The panels were taken into the

laboratory after 1, 2, 4, and 8 weeks of aging, the exposure time required to give 100% mortality of duplicate sets of five male roaches on each panel was determined. The roaches were confined on the panels under plastic dishes dusted inside with pyrophyllite to prevent them from leaving the treated surface. After exposure for ½ to 24 hours, the roaches were removed to clean petri dishes and mortality counts made after 48 hours. If complete kill was not obtained with a 24-hour exposure the roaches were confined on the panels continuously and mortality noted every 24 hours. Water and dog food were provided if exposure periods exceeded 48 hours. After aging for one week, chlordane was the most effective insecticide tested.

Resistant strains of roaches within known age limits were obtained by removing all adults from resistant stock cultures at 5 to 7-day intervals. For treatment, they were placed in a small screen cage, approximately 30 per cage and dipped for a period of 10 seconds in DDT suspensions at 30°C. Mortality counts were made at the end of 72 and 144 hours after treatment. Roaches that were unable to exhibit active locomotion were counted as dead (Grayson, 1951).

MATERIALS AND METHODS

Three methods of testing, viz. feeding insecticides mixed in food, dipping in insecticides and exposure for limited periods to treated surfaces were conducted in the laboratory at room temperature.

The German roach, Blattella germanica (Linnaeus), the oriental roach, Blatta orientalis Linnaeus, and the smokey-brown roach, Periplaneta fuliginosa (Serville) were used as the test insects. Adults of different age and sex, taken from laboratory cultures were used in all the tests. Prior to each test the roaches were transferred from laboratory cultures to a one gallon size glass jar with a square of cheesecloth tightly fitted over the top. Roaches were anesthetized with ether to facilitate handling.

The roaches were divided into groups of 10 for each treatment. Each treatment was replicated five times at two different concentrations as follows:

INSECTICIDE	PERCENT SOLUTION	PERCENT SOLUTION
Dieldrin	0.5	0.25
Chlordane	2.0	1.0
Heptachlor	0.5	0.25
DDT	5.0	2.5
Diazinon	0.5	0.25
Malathion	2.0	1.0

The tests involved 30 replicated treatments on 15 different days. Two replicates of all treatments including controls were done on the same day at each concentration. Roaches treated under the various testing methods were held for observation in 1 quart size ice cream containers fitted with fine wire mesh tops. Mortality counts at each dosage level were recorded at 12, 24, 36, 48, and 72 hours after treatment.

FEEDING

The feeding of measured doses of toxicants to oriental roaches was accomplished by applying 2 ml of insecticide with a DeVilbiss atomizer to one teaspoonful of freshly ground Purina dog chow. After thorough mixing, the mixture was allowed to dry before being offered to the roaches. Ten roaches were placed in each ice cream container with the food mixture and provided with water. No other source of food was supplied. Prior to testing, the roaches were starved for 24 hours to stimulate feeding.

At the end of the three-day observation period the remaining food in each container was measured to determine how much had been consumed.

DIPPING

Each replicate of immobilized smokey-brown roaches was placed in a small cheesecloth bag one inch in diameter

and three inches long. The open ends of the bags were secured with rubber bands to prevent roaches from escaping.

As soon as the roaches recovered from the effects of anesthesia, each replicate was dipped in a beaker containing 50 milliliters of insecticide dissolved in acetone for five seconds and immediately transferred to an observation carton provided with filter paper to absorb any excess liquid. Freshly ground Purina dog chow and water were supplied.

Prior to treatment the roaches were starved for 24 hours.

EXPOSURE TO TREATED SURFACES

Two milliliters of toxicant applied with a DeVilbiss atomizer to petri dishes fitted with Reynolds wrap, served as the treated surface. Treated surfaces were allowed to dry for three hours before the German roaches were exposed to them. After two hours of exposure to the dry residual film, the roaches were removed with the aid of tweezers to recovery containers which were provided with freshly ground Purina dog chow and water.

RESULTS

The results of testing four chlorinated hydrocarbons and two organophosphorus insecticides against three species of cockroaches are summarized in Tables 1 to 36. Percentage mortalities recorded at 24, 48, and 72 hours after treatment (Appendix I to XXXVI) were converted to the arcsin percentage transformation and analyzed. The data obtained from the controls were not analyzed statistically but are presented in Tables I to XXXVI of the appendix.

A total of 1800 cockroaches were tested with the 6 toxicants under the three testing methods, 600 under each method. The effectiveness of the three test methods compared favorably with each other. At the low concentrations, mortality counts were lower after 24 hours than at the high concentrations, but after 48 and 72 hours mortalities were comparable at both concentrations.

Tables 7 to 12, 19 to 24 and 31 to 36 compare the 6 treatments in each replicate using Duncan's new multiple-range test. Any two means not underscored by the same line are significantly different. There was a significant difference between DDT and all the other treatments.

FEEDING EXPERIMENTS

The results of feeding insecticides mixed into the food of Blatta orientalis are presented in Tables 1 through 12.

These results, based on percentage mortality, show some significant differences depending on the insecticide used and the length of exposure.

Data summarized in Table 7 showed that Diazinon, malathion and dieldrin were not significantly different at the 5% level. There was no significant difference between heptachlor or chlordane, but all five treatments were better than DDT, at the 5% level.

Data summarized in Table 8 showed no significant differences between Diazinon, chlordane, malathion, dieldrin and heptachlor. All five treatments were significantly better than DDT, at the 5% level.

Data summarized in Tables 9 and 10 also showed no significant difference between the treatments with malathion, Diazinon, heptachlor, chlordane and dieldrin. All the treatments were significantly better than DDT, at the 5% level.

Data summarized in Tables 11 and 12 showed no significant differences between the treatments with malathion, Diazinon and chlordane. There was no significant difference between heptachlor or dieldrin but all five treatments were better than DDT, at the 5% level.

DIPPING EXPERIMENTS

The results of dipping Periplaneta fuliginosa in insecticides for 5 seconds are presented in Tables 13

through 24. These results, based on percentage mortality, show some significant differences depending on the insecticide used and the length of exposure.

Data summarized in Table 19 showed Diazinon and malathion to be significantly better than the other treatments. There was no significant difference between chlordane, heptachlor or dieldrin and all the treatments were better than DDT, at the 5% level.

Data summarized in Table 20 showed that dieldrin, Diazinon and malathion were not significantly different from each other. There was no significant difference between chlordane or heptachlor, but all five treatments were better than DDT, at the 5% level.

Data summarized in Table 21 showed that dieldrin, Diazinon, malathion, chlordane and heptachlor were not significantly different but all five treatments were better than DDT, at the 5% level.

Data summarized in Tables 22 and 23 showed that there was no significant difference between Diazinon and malathion or between dieldrin, chlordane and heptachlor. All the treatments were significantly better than DDT, at the 5% level.

Data summarized in Table 24 showed that Diazinon, malathion and dieldrin were not significantly different from each other. There was no significant difference between heptachlor and chlordane, but all five treatments were better than DDT, at the 5% level.

EXPOSURE TO TREATED SURFACES

The results of exposing Blattella germanica to surfaces treated with insecticides are presented in Tables 25 through 36. These results, based on percentage mortality show some significant differences depending on the insecticide used and the length of exposure.

Data summarized in Table 31 showed no significant difference between Diazinon and malathion or between dieldrin, chlordane and heptachlor but all of the five treatments were significantly better than DDT, at the 5% level.

Data summarized in Table 32 showed no significant difference between Diazinon, malathion and dieldrin. Chlordane and heptachlor were not significantly different from each other, but all five treatments were better than DDT, at the 5% level.

Data summarized in Tables 33 and 34 showed no significant difference between Diazinon, heptachlor, malathion, dieldrin or chlordane but all the treatments were significantly better than DDT, at the 5% level.

Data summarized in Table 35 showed no significant difference between Diazinon and malathion or between chlordane, dieldrin and heptachlor but all five treatments were significantly better than DDT, at the 5% level.

Data summarized in Table 36 showed no significant difference between Diazinon, malathion, dieldrin, chlordane

or heptachlor but all five treatments were significantly better than DDT, at the 5% level.

When the results presented in Tables 1 to 6, 13 to 18 and 25 to 30 were tested by the analysis of variance, significant differences were indicated between the treatment means in each replicate. These differences were due to variation among individual reaches within a replicate and possibly to the fact that all the experiments were not conducted on the same day.

FEEDING EXPERIMENTS

TABLE 1. -- Mortality of Blatta orientalis after 24 hours when fed insecticides mixed into their food.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.5	71.56	90.00	90.00	90.00	71.56	82.62
Chlordane	2.0	56.79	50.77	90.00	71.56	56.79	65.18
Heptachlor	0.5	63.44	56.79	90.00	71.56	56.79	67.72
DDT	5.0	39.23	45.00	50.77	39.23	33.21	41.49
Diazinon	0.5	90.00	90.00	90.00	90.00	90.00	90.00
Malathion	2.0	56.79	90.00	90.00	90.00	90.00	83.36

Analysis of Variance

Source of variation	Degrees of freedom	Sums of squares	Mean squares	F
1	Reps. 4	1548.01841	387.00460	
2	Trts. 5	7806.24780	1561.24956	18.44*
Residual	Error 20	1693.11847	84.65592	
TOTAL	29	11047.38468		

TABLE 2. -- Mortality of Blatta orientalis after 48 hours when fed insecticides mixed into their food.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.5	71.56	90.00	90.00	90.00	71.56	82.62
Chlordane	2.0	90.00	63.44	90.00	90.00	90.00	84.69
Heptachlor	0.5	71.56	71.56	90.00	90.00	71.56	78.94
DDT	5.0	50.77	50.77	50.77	50.77	50.77	50.77
Diazinon	0.5	90.00	90.00	90.00	90.00	90.00	90.00
Malathion	2.0	56.79	90.00	90.00	90.00	90.00	83.36

Analysis of Variance

Source of variation	Degrees of freedom	Sums of squares	Mean squares	F
1	Reps. 4	613.12772	153.28193	
2	Trts. 5	4901.13492	980.22698	11.88*
Residual	Error 20	1649.62308	82.48115	
TOTAL	29	7163.88572		

TABLE 3. -- Mortality of Blatta orientalis after 72 hours when fed insecticides mixed into their food.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate 1	2	3	4	5	Av. % mort.
Dieldrin	0.5	71.56	90.00	90.00	90.00	71.56	82.62
Chlordane	2.0	90.00	63.44	90.00	90.00	90.00	84.69
Heptachlor	0.5	90.00	90.00	90.00	90.00	90.00	90.00
DDT	5.0	50.77	63.44	56.79	56.79	63.44	58.24
Diazinon	0.5	90.00	90.00	90.00	90.00	90.00	90.00
Malathion	2.0	63.44	90.00	90.00	90.00	90.00	84.69

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	294.98882	73.74721	
2	Trts.	5	3532.89914	706.57983	10.42*
Residual	Error	20	1355.83098	67.79155	
TOTAL		29	5183.71894		

TABLE 4. -- Mortality of Blatta orientalis after 24 hours when fed insecticides mixed into their food.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate 1	2	3	4	5	Av. % mort.
Dieldrin	0.25	45.00	39.23	50.77	33.21	56.79	45.00
Chlordane	1.0	45.00	63.44	50.77	39.23	50.77	49.84
Heptachlor	0.25	56.79	39.23	56.79	56.79	45.00	50.92
DDT	2.5	33.21	33.21	33.21	33.21	26.56	31.88
Diazinon	0.25	71.56	33.21	45.00	56.79	63.44	54.00
Malathion	1.0	56.79	63.44	50.77	63.44	56.79	58.25

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	136.29081	34.07270	
2	Trts.	5	2105.80095	421.16019	4.49*
Residual	Error	20	1874.00299	93.70015	
TOTAL		29	4116.09475		

TABLE 5. -- Mortality of Blatta orientalis after 48 hours when fed insecticides mixed into their food.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.25	63.44	56.76	63.44	45.00	63.44	58.42
Chlordane	1.0	71.56	71.56	71.56	56.76	71.56	68.60
Heptachlor	0.25	56.79	50.77	71.56	63.44	71.56	62.82
DDT	2.5	45.00	33.21	45.00	45.00	39.23	41.49
Diazinon	0.25	90.00	45.00	90.00	90.00	63.44	75.69
Malathion	1.0	71.56	71.56	90.00	71.56	90.00	78.94

Analysis of Variance

Source of variation	Degrees of freedom	Sums of squares	Mean squares	F
1	Reps. 4	978.50245	244.62561	
2	Trts. 5	4597.86283	919.57257	9.13*
Residual	Error 20	2014.83907	100.74195	
TOTAL	29	7591.20435		

TABLE 6. -- Mortality of Blatta orientalis after 72 hours when fed insecticides mixed into their food.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.25	63.44	63.44	90.00	50.77	63.44	66.22
Chlordane	1.0	71.56	90.00	90.00	90.00	90.00	86.31
Heptachlor	0.25	71.56	56.76	71.56	63.44	90.00	70.66
DDT	2.5	45.00	33.21	50.77	45.00	50.77	44.95
Diazinon	0.25	90.00	56.79	90.00	90.00	90.00	83.36
Malathion	1.0	90.00	71.56	90.00	71.56	90.00	82.62

Analysis of Variance

Source of variation	Degrees of freedom	Sums of squares	Mean squares	F
1	Reps. 4	1395.32629	348.83157	
2	Trts. 5	6064.36246	1212.87249	13.32*
Residual	Error 20	1821.01159	91.05058	
TOTAL	29	9280.70034		

TABLE 7. -- The percent mortality of Blatta orientalis fed insecticide mixed into their food, at the high concentration.

Treatment	Percent mortality (24 hours) [a]	[b]
Diazinon	90.00	
Malathion	83.36	
Dieldrin	82.62	
Heptachlor	67.72	
Chlordane	65.18	
DDT	41.49	

TABLE 8. -- The percent mortality of Blatta orientalis fed insecticide mixed into their food, at the high concentration.

Treatment	Percent mortality (48 hours) [a]	[b]
Diazinon	90.00	
Chlordane	84.69	
Malathion	83.36	
Dieldrin	82.62	
Heptachlor	78.94	
DDT	50.77	

(a) Average mortality of 5 replicates containing 10 insects.

(b) Means not underscored by the same line are significantly different at the 5% level using Duncan's new multiple-range test.

TABLE 9. -- The percent mortality of Blatta orientalis fed insecticide mixed into their food, at the high concentration.

Treatment	Percent mortality (72 hours) a)	b)
Heptachlor	90.00	
Diazinon	90.00	
Chlordane	84.69	
Malathion	84.69	
Dieldrin	82.62	
DDT	58.24	

TABLE 10. -- The percent mortality of Blatta orientalis fed insecticide mixed into their food, at the low concentration.

Treatment	Percent mortality 24 hours) a)	b)
Malathion	58.25	
Diazinon	54.00	
Heptachlor	50.92	
Chlordane	49.84	
Dieldrin	45.00	
DDT	31.88	

(a) Average mortality of 5 replicates containing 10 insects

(b) Means not underscored by the same line are significantly different at the 5% level using Duncan's new multiple-range test.

TABLE 11. -- The percent mortality of Blatta orientalis fed insecticide mixed into their food, at the low concentration.

Treatment	Percent mortality[a] (48 hours)	b)
Malathion	78.94	
Diazinon	75.69	
Chlordane	68.60	
Heptachlor	62.82	
Dieldrin	58.42	
DDT	41.49	

TABLE 12. -- The percent mortality of Blatta orientalis fed insecticide mixed into their food, at the low concentration.

Treatment	Percent mortality[a] (72 hours)	b)
Chlordane	86.31	
Diazinon	83.36	
Malathion	82.62	
Heptachlor	70.66	
Dieldrin	66.22	
DDT	44.95	

(a) Average mortality of 5 replicates containing 10 insects.

(b) Means not underscored by the same line are significantly different at the 5% level using Duncan's new multiple-range test.

DIPPING EXPERIMENTS

TABLE 13. -- Mortality of Periplaneta fuliginosa after 24 hours when dipped in insecticides for 5 seconds.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.5	63.44	63.44	63.44	63.44	71.56	65.04
Chlordane	2.0	71.56	71.56	71.56	63.44	63.44	68.31
Heptachlor	0.5	71.56	71.56	63.44	63.44	63.44	66.69
DDT	5.0	45.00	39.23	33.21	33.21	39.23	37.98
Diazinon	0.5	90.00	90.00	90.00	90.00	90.00	90.00
Malathion	2.0	90.00	90.00	71.56	71.56	63.44	77.31

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	310.89708	77.72427	
2	Trts.	5	7407.12027	1481.42405	51.21*
Residual	Error	20	578.57820	28.92891	
TOTAL		29	8296.59555		

TABLE 14. -- Mortality of Periplaneta fuliginosa after 48 hours when dipped in insecticides for 5 seconds.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.5	90.00	90.00	90.00	90.00	90.00	90.00
Chlordane	2.0	71.56	71.56	90.00	71.56	90.00	78.94
Heptachlor	0.5	71.56	90.00	63.44	71.56	90.00	77.31
DDT	5.0	56.79	50.77	50.77	45.00	56.79	52.04
Diazinon	0.5	90.00	90.00	90.00	71.56	90.00	86.31
Malathion	2.0	90.00	90.00	90.00	71.56	90.00	86.31

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	649.46479	162.36620	
2	Trts.	5	4784.41451	956.88290	19.51*
Residual	Error	20	981.11449	49.05572	
TOTAL		29	6414.99379		

TABLE 15. -- Mortality of Periplaneta fuliginosa after 72 hours when dipped in insecticides for 5 seconds.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.5	90.00	90.00	90.00	90.00	90.00	90.00
Chlordane	2.0	71.56	90.00	90.00	90.00	90.00	86.31
Heptachlor	0.5	90.00	90.00	63.44	71.56	90.00	81.00
DDT	5.0	63.44	50.77	56.79	63.44	56.79	58.25
Diazinon	0.5	90.00	90.00	90.00	90.00	90.00	90.00
Malathion	2.0	90.00	90.00	90.00	90.00	90.00	90.00

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	64.85031	16.21258	
2	Trts.	5	3867.70602	773.54120	16.09*
Residual	Error	20	961.43077	48.07154	
TOTAL		29	4893.98710		

TABLE 16. -- Mortality of Periplaneta fuliginosa after 24 hours when dipped in insecticides for 5 seconds.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.25	50.77	50.77	45.00	45.00	45.00	47.31
Chlordane	1.0	45.00	50.77	33.21	45.00	39.23	42.64
Heptachlor	0.25	50.77	56.79	33.21	39.23	33.21	42.64
DDT	2.5	33.21	26.56	26.56	26.56	26.56	27.89
Diazinon	0.25	63.44	56.79	50.77	50.77	56.79	55.71
Malathion	1.0	50.77	63.44	45.00	50.77	50.77	52.15

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	601.40155	150.35039	
2	Trts.	5	2373.05840	474.61168	23.57*
Residual	Error	20	402.70697	20.13535	
TOTAL		29	3377.16692		

TABLE 17. -- Mortality of Periplaneta fuliginosa after 48 hours when dipped in insecticides for 5 seconds.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate 1	2	3	4	5	Av. % mort.
Dieldrin	0.25	63.44	63.44	63.44	56.79	45.00	58.42
Chlordane	1.0	50.77	63.44	50.77	56.79	71.56	57.47
Heptachlor	0.25	71.56	56.79	50.77	56.79	50.77	57.34
DDT	2.5	39.23	39.23	39.23	39.23	45.00	40.38
Diazinon	0.25	71.56	71.56	71.56	63.44	63.44	68.31
Malathion	1.0	71.56	90.00	56.79	90.00	90.00	79.67

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	241.12685	60.28171	
2	Trts.	5	4281.74534	856.34907	10.14*
Residual	Error	20	1689.82855	84.49143	
TOTAL		29	6212.70074		

TABLE 18. -- Mortality of Periplaneta fuliginosa after 72 hours when dipped in insecticides for 5 seconds.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate 1	2	3	4	5	Av. % mort.
Dieldrin	0.25	90.00	90.00	90.00	90.00	63.44	84.69
Chlordane	1.0	56.79	90.00	63.44	56.79	90.00	71.40
Heptachlor	0.25	90.00	71.56	71.56	56.79	71.56	72.29
DDT	2.5	50.77	45.00	45.00	39.23	45.00	45.00
Diazinon	0.25	90.00	90.00	90.00	90.00	90.00	90.00
Malathion	1.0	71.56	90.00	90.00	90.00	90.00	86.31

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	240.84135	60.21034	
2	Trts.	5	6835.28570	1367.05714	11.39*
Residual	Error	20	2399.79665	119.98983	
TOTAL		29	9475.92370		

TABLE 19. -- The percent mortality of Periplaneta fuliginosa dipped in insecticide for 5 seconds, at the high concentration.

Treatment	Percent mortality[a] (24 hours)	
Diazinon	90.00	
Malathion	77.31	
Chlordane	68.31	b)
Heptachlor	66.69	
Dieldrin	65.04	
DDT	37.98	

TABLE 20. -- The percent mortality of Periplaneta fuliginosa dipped in insecticide for 5 seconds, at the high concentration.

Treatment	Percent mortality[a] (48 hours)	
Dieldrin	90.00	b)
Diazinon	86.31	
Malathion	86.31	
Chlordane	78.94	
Heptachlor	77.31	
DDT	52.04	

(a) Average mortality of 5 replicates containing 10 insects.

(b) Means not underscored by the same line are significantly different at the 5% level using Duncan's new multiple-range test.

TABLE 21. -- The percent mortality of Periplaneta fuliginosa dipped in insecticide for 5 seconds, at the high concentration.

Treatment	Percent mortality[a] (72 hours)	b)
Dieldrin	90.00	
Diazinon	90.00	
Malathion	90.00	
Chlordane	86.31	
Heptachlor	81.00	
DDT	58.25	

TABLE 22. -- The percent mortality of Periplaneta fuliginosa dipped in insecticide for 5 seconds, at the low concentration.

Treatment	Percent mortality[a] (24 hours)	b)
Diazinon	55.71	
Malathion	52.15	
Dieldrin	47.31	
Chlordane	42.64	
Heptachlor	42.64	
DDT	27.89	

(a) Average mortality of 5 replicates containing 10 insects.

(b) Means not underscored by the same line are significantly different at the 5% level using Duncan's new multiple-range test.

TABLE 23. -- The percent mortality of Periplaneta fuliginosa dipped in insecticide for 5 seconds, at the low concentration.

Treatment	Percent mortality[a] (48 hours)	b)
Malathion	79.67	
Diazinon	68.31	
Dieldrin	58.42	
Chlordane	57.47	
Heptachlor	57.34	
DDT	40.38	

TABLE 24. -- The percent mortality of Periplaneta fuliginosa dipped in insecticide for 5 seconds, at the low concentration.

Treatment	Percent mortality[a] (72 hours)	b)
Diazinon	90.00	
Malathion	86.31	
Dieldrin	84.69	
Heptachlor	72.29	
Chlordane	71.40	
DDT	45.00	

(a) Average mortality of 5 replicates containing 10 insects.

(b) Means not underscored by the same line are significantly different at the 5% level using Duncan's new multiple-range test.

RESIDUE EXPERIMENTS

TABLE 25. -- Mortality of Blattella germanica after 24 hours when exposed to surfaces treated with insecticides.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.5	71.56	63.44	71.56	56.79	90.00	70.67
Chlordane	2.0	63.44	71.56	63.44	71.56	56.79	65.36
Heptachlor	0.5	71.56	71.56	63.44	56.79	63.44	65.36
DDT	5.0	18.44	18.44	26.56	39.23	33.21	27.18
Diazinon	0.5	71.56	90.00	90.00	90.00	90.00	86.31
Malathion	2.0	63.44	90.00	71.56	90.00	63.44	75.69

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	231.51428	57.87857	
2	Trts.	5	10157.21126	2031.44225	19.94*
Residual	Error	20	2037.52536	101.87627	
TOTAL		29	12426.25090		

TABLE 26. -- Mortality of Blattella germanica after 48 hours when exposed to surfaces treated with insecticides.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.5	90.00	63.44	71.56	71.56	90.00	71.31
Chlordane	2.0	71.56	71.56	90.00	71.56	63.44	73.62
Heptachlor	0.5	90.00	71.56	71.56	71.56	63.44	73.62
DDT	5.0	50.77	39.23	39.23	45.00	56.79	46.20
Diazinon	0.5	90.00	90.00	90.00	90.00	90.00	90.00
Malathion	2.0	63.44	90.00	90.00	90.00	71.56	81.00

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	101.73939	25.43485	
2	Trts.	5	5440.18215	1088.03643	10.26*
Residual	Error	20	2120.27165	106.01358	
TOTAL		29	7662.19319		

TABLE 27. -- Mortality of Blattella germanica after 72 hours when exposed to surfaces treated with insecticides.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.5	90.00	90.00	71.56	71.56	90.00	82.62
Chlordane	2.0	90.00	71.56	90.00	90.00	63.44	81.00
Heptachlor	0.5	90.00	90.00	90.00	90.00	71.56	86.31
DDT	5.0	56.79	45.00	50.77	50.77	56.79	52.02
Diazinon	0.5	90.00	90.00	90.00	90.00	90.00	90.00
Malathion	2.0	63.44	90.00	90.00	90.00	90.00	84.69

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	49.69481	12.42370	
2	Trts.	5	4752.43995	950.48799	9.83*
Residual	Error	20	1933.09759	96.65488	
TOTAL		29	6735.23235		

TABLE 28. -- Mortality of Blattella germanica after 24 hours when exposed to surfaces treated with insecticides.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.25	39.23	39.23	39.23	50.77	45.00	42.69
Chlordane	1.0	45.00	50.77	39.23	39.23	45.00	43.85
Heptachlor	0.25	33.21	39.23	39.23	26.56	33.21	34.29
DDT	2.5	0	0	33.21	39.23	26.56	19.80
Diazinon	0.25	45.00	45.00	45.00	39.23	26.56	40.16
Malathion	1.0	45.00	45.00	26.56	50.77	50.77	43.62

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	130.49269	32.62317	
2	Trts.	5	2176.47843	435.29569	3.92*
Residual	Error	20	2220.48727	111.02436	
TOTAL		29	4527.45839		

TABLE 29. -- Mortality of Blattella germanica after 48 hours when exposed to surfaces treated with insecticides.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.25	56.79	63.44	45.00	71.56	56.79	58.72
Chlordane	1.0	71.56	56.79	56.79	56.79	56.79	59.74
Heptachlor	0.25	56.79	56.79	63.44	50.77	56.79	56.91
DDT	2.5	50.77	33.21	45.00	39.23	33.21	40.29
Diazinon	0.25	90.00	71.56	71.56	90.00	71.56	78.94
Malathion	1.0	56.79	90.00	90.00	63.44	71.56	74.36

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	118.05362	29.51341	
2	Trts.	5	4756.53906	951.30781	9.12*
Residual	Error	20	2086.12586	104.30629	
TOTAL		29	6960.71854		

TABLE 30. -- Mortality of Blattella germanica after 72 hours when exposed to surfaces treated with insecticides.

Treatment	Dosage (% sol. in acetone)	Percent mortality in replicate					Av. % mort.
		1	2	3	4	5	
Dieldrin	0.25	71.56	90.00	63.44	71.56	90.00	77.31
Chlordane	1.0	90.00	63.44	71.56	90.00	56.79	74.36
Heptachlor	0.25	90.00	56.79	90.00	56.79	63.44	71.40
DDT	2.5	50.77	45.00	45.00	39.23	45.00	45.00
Diazinon	0.25	90.00	90.00	90.00	90.00	71.56	86.31
Malathion	1.0	63.44	90.00	90.00	63.44	90.00	79.38

Analysis of Variance

Source of variation		Degrees of freedom	Sums of squares	Mean squares	F
1	Reps.	4	259.23785	64.80946	
2	Trts.	5	5109.27002	1021.85400	5.66*
Residual	Error	20	3613.66543	180.68327	
TOTAL		29	8982.17330		

TABLE 31. -- The percent mortality of Blattella germanica exposed to surfaces treated with insecticides, at the high concentration.

Treatment	Percent mortality[a] (24 hours)	b)
Diazinon	86.31	
Malathion	75.69	
Dieldrin	70.67	
Chlordane	65.36	
Heptachlor	65.36	
DDT	27.18	

TABLE 32. -- The percent mortality of Blattella germanica exposed to surfaces treated with insecticides, at the high concentration.

Treatment	Percent mortality[a] (48 hours)	b)
Diazinon	90.00	
Malathion	81.00	
Dieldrin	71.31	
Chlordane	73.62	
Heptachlor	73.62	
DDT	46.20	

(a) Average mortality of 5 replicates containing 10 insects.

(b) Means not underscored by the same line are significantly different at the 5% level using Duncan's new multiple-range test.

TABLE 33. -- The percent mortality of Blattella germanica exposed to surfaces treated with insecticides, at the high concentration.

Treatment	Percent mortality[a] (72 hours)	[b]
Diazinon	90.00	
Heptachlor	86.31	
Malathion	84.69	
Dieldrin	82.62	
Chlordane	81.00	
DDT	52.02	

TABLE 34. -- The percent mortality of Blattella germanica exposed to surfaces treated with insecticides, at the low concentration.

Treatment	Percent mortality[a] (24 hours)	[b]
Chlordane	43.85	
Malathion	43.62	
Dieldrin	42.69	
Diazinon	40.16	
Heptachlor	34.29	
DDT	19.80	

(a) Average mortality of 5 replicates containing 10 insects.

(b) Means not underscored by the same line are significantly different at the 5% level using Duncan's new multiple-range test.

TABLE 35. -- The percent mortality of Blattella germanica exposed to surfaces treated with insecticides, at the low concentration.

Treatment	Percent mortality[a] (48 hours)	b)
Diazinon	78.94	
Malathion	74.36	
Chlordane	59.74	
Dieldrin	58.72	
Heptachlor	56.92	
DDT	40.29	

TABLE 36. -- The percent mortality of Blattella germanica exposed to surfaces treated with insecticides, at the low concentration.

Treatment	Percent mortality[a] (72 hours)	b)
Diazinon	86.31	
Malathion	79.38	
Dieldrin	77.31	
Chlordane	74.36	
Heptachlor	71.40	
DDT	45.00	

(a) Average mortality of 5 replicates containing 10 insects.

(b) Means not underscored by the same line are significantly different at the 5% level using Duncan's new multiple-range test.

SUMMARY AND CONCLUSIONS

Cockroaches are amongst the most important household pests due to the nuisance they cause as well as the obnoxious odor they impart to food over which they crawl and the various diseases they may transmit. Cockroach control is expensive but necessary and a great scientific breakthrough was achieved with the advent of two organophosphorus insecticides, Diazinon and malathion, which can adequately control populations resistant to DDT, chlordane or dieldrin.

This study was undertaken to determine the effectiveness of four chlorinated hydrocarbons, DDT, chlordane, heptachlor, dieldrin and two organophosphorus insecticides, Diazinon and malathion. The roaches tested were the German roach, Blattella germanica (Linnaeus), the oriental roach, Blatta orientalis Linnaeus, and the smokey-brown roach, Periplaneta fuliginosa (Serville). Each treatment was replicated five times at two different concentrations for the three test methods. The concentrations used were: dieldrin 0.5 and 0.25 percent solution, chlordane 2.0 and 1.0 percent solution, DDT 5.0 and 2.5 percent solution, heptachlor 0.5 and 0.25 percent solution, Diazinon 0.5 and 0.25 percent solution and malathion 2.0 and 1.0 percent solution.

In this study, all the roaches were held for 72 hours after application of insecticides, at room temperature,

in 1 quart-size ice cream containers. The tops of the containers were removed and replaced with wire screens to make observation possible. Mortality counts were made at 12, 24, 36, 48 and 72 hours, but the resulting kill was statistically analyzed only at 24, 48 and 72 hours after treatment. A total of 2100 roaches were tested. All the roaches were adults of different ages and mixed sexes taken from laboratory cultures. Before each treatment the required number of roaches were transferred from the original cultures to a 1 gallon-size glass jar and anesthetized for approximately 5 minutes with ether to facilitate handling. Groups of 10 were then counted out for appropriate treatment.

The toxicants were tested against the roaches by three methods in the following sequence:

a) Feeding insecticides mixed in food to the oriental roach, Blatta orientalis.

b) Dipping smokey-brown roach, Periplaneta fuliginosa, in insecticides.

c) Exposing German roach, Blattella germanica, to insecticide treated surfaces.

FEEDING EXPERIMENTS

Cockroaches were starved for 24 hours before each experiment in an attempt to stimulate feeding activity. Each treatment was prepared by applying 2 milliliters of

insecticide to a tablespoonful of ground dog food with a DeVilbiss atomizer. A different atomizer was used in the application of each toxicant. The mixtures were allowed to dry for 1 hour and then offered to the roaches in holding containers, on filter paper. No source of food was made available but water was provided.

DIPPING EXPERIMENTS

The smokey-brown roaches tested were taken from laboratory cultures and starved 24 hours in a small wire cage before treatment. They were anesthetized with ether and groups of 10 were selected and transferred to small cheesecloth bags 1 inch in diameter and 3 inches long. The roaches were kept in the bags for 30 minutes until they fully recovered from the anesthesia.

Each bag containing 10 roaches was dipped in the test liquid in a 125 milliliter beaker for 5 seconds. The roaches were immediately transferred to holding containers. Excess liquid from the body of the roaches was absorbed by filter paper fitted at the bottom of each container. The roaches were provided with freshly ground dog food and water. The food was placed on filter paper at the bottom of the containers.

EXPOSURE TO TREATED SURFACES

German roaches were exposed to 2 milliliters of toxicant applied to aluminum foil (Reynolds wrap) fitted over the bottom of petri dishes, after the toxicant had dried for approximately 3 hours. The roaches were exposed to the treated surface for a period of 2 hours. The upper half of each petri dish was replaced by fine wire screen to keep the test insects from escaping. At the end of the exposure period, the roaches were transferred to clean recovery containers, and provided with freshly ground dog food and water.

The results of the three test methods (feeding, dipping and exposure to treated surfaces) used in this study were statistically analyzed (Tables 1 to 36). Diazinon and malathion with some exceptions were the quickest acting insecticides tested against the three species of roaches. This finding concurs with the report of Grayson (1964) that Diazinon is one of the most effective materials against roaches.

DDT was relatively slow acting and when tested by Duncan's new multiple-range test, Tables 7 to 12, 19 to 24 and 31 to 36, was found significantly different from the other treatments. All the data obtained from these experiments suggest that dieldrin, chlordane, heptachlor, Diazinon

and malathion can adequately control populations of German, oriental and smokey-brown roaches. DDT was not very effective in these tests and the other five insecticides were found to be significantly better.

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APPENDIX

TABLE I. -- Percent mortality in Blatta orientalis after 24 hours when fed insecticides mixed into their food, at high concentration.

Treatment	Percent mortality in replicate 1	2	3	4	5	Av. % mort.
Dieldrin	90	100	100	100	90	96
Chlordane	70	60	100	90	70	78
Heptachlor	80	70	100	90	70	82
DDT	40	50	60	40	30	44
Diazinon	100	100	100	100	100	100
Malathion	70	100	100	100	100	94
Control	0	0	0	0	0	0

TABLE II. -- Percent mortality of Blatta orientalis after 48 hours when fed insecticides mixed into their food, at high concentration.

Treatment	Percent mortality in replicate 1	2	3	4	5	Av. % mort.
Dieldrin	90	100	100	100	90	96
Chlordane	100	80	100	100	100	96
Heptachlor	90	90	100	100	90	94
DDT	60	60	60	60	60	60
Diazinon	100	100	100	100	100	100
Malathion	70	100	100	100	100	94
Control	0	0	0	0	0	4

TABLE III. -- Percent mortality of Blatta orientalis after 72 hours when fed insecticides mixed into their food, at high concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	90	100	100	100	90	96
Chlordane	100	80	100	100	100	96
Heptachlor	100	100	100	100	100	100
DDT	60	80	70	70	80	72
Diazinon	100	100	100	100	100	100
Malathion	80	100	100	100	100	96
Control	0	10	10	10	0	6

TABLE IV. -- Percent mortality of Blatta orientalis after 24 hours when fed insecticides mixed into their food, at low concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	50	40	60	30	70	50
Chlordane	50	80	60	40	60	58
Heptachlor	70	40	70	70	50	60
DDT	30	30	30	30	20	28
Diazinon	90	30	50	70	80	64
Malathion	70	80	60	80	70	72
Control	0	0	0	0	0	0

TABLE V. -- Percent mortality of Blatta orientalis after 48 hours when fed insecticides mixed into their food, at low concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	80	70	80	50	80	72
Chlordane	90	90	90	70	90	82
Heptachlor	70	60	90	80	90	78
DDT	50	30	50	50	40	44
Diazinon	100	50	100	100	80	82
Malathion	90	90	100	90	100	94
Control	0	0	10	10	0	4

TABLE VI. -- Percent mortality of Blatta orientalis after 72 hours when fed insecticides mixed into their food, at low concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	80	80	100	60	80	80
Chlordane	90	100	100	100	100	98
Heptachlor	90	70	90	80	100	82
DDT	50	30	60	50	60	50
Diazinon	100	70	100	100	100	94
Malathion	100	90	100	90	100	96
Control	0	0	20	10	0	6

TABLE VII. -- Percent mortality of Periplaneta fuliginosa after 24 hours when dipped into insecticides for 5 seconds, at high concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	80	80	80	80	90	82
Chlordane	90	90	90	80	80	86
Heptachlor	90	90	80	80	80	84
DDT	50	40	30	30	40	38
Diazinon	100	100	100	100	100	100
Malathion	100	100	90	90	80	92
Control	0	0	0	0	0	0

TABLE VIII. -- Percent mortality of Periplaneta fuliginosa after 48 hours when dipped into insecticides for 5 seconds, at high concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	100	100	100	100	100	100
Chlordane	90	90	100	90	100	94
Heptachlor	90	100	80	90	100	92
DDT	70	60	60	50	70	62
Diazinon	100	100	100	100	100	100
Malathion	100	100	100	100	100	100
Control	0	0	0	0	0	0

TABLE IX. -- Percent mortality of Periplaneta fuliginosa after 72 hours when dipped into insecticides for 5 seconds, at high concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	100	100	100	100	100	100
Chlordane	90	100	100	100	100	98
Heptachlor	100	100	80	90	100	94
DDT	80	60	70	80	70	72
Diazinon	100	100	100	100	100	100
Malathion	100	100	100	100	100	100
Control	0	10	0	0	10	4

TABLE X. -- Percent mortality of Periplaneta fuliginosa after 24 hours when dipped into insecticides for 5 seconds, at low concentration.

Treatment	Percent mortality in replicate					Av. mort.
	1	2	3	4	5	
Dieldrin	60	60	50	50	50	54
Chlordane	50	60	30	50	40	46
Heptachlor	60	70	30	40	30	46
DDT	30	20	20	20	20	22
Diazinon	80	70	60	60	70	69
Malathion	60	80	50	60	60	62
Control	0	0	0	0	0	0

TABLE XI. -- Percent mortality of Periplaneta fuliginosa after 48 hours when dipped into insecticides for 5 seconds, at low concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	80	80	80	70	50	72
Chlordane	60	80	60	60	90	70
Heptachlor	90	70	60	70	60	70
DDT	40	40	40	40	50	42
Diazinon	90	90	90	80	80	86
Malathion	90	100	70	100	100	92
Control	0	10	10	10	0	6

TABLE XII. -- Percent mortality of Periplaneta fuliginosa after 72 hours when dipped into insecticides for 5 seconds, at low concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	100	100	100	100	80	96
Chlordane	70	100	80	70	100	84
Heptachlor	100	90	90	70	90	88
DDT	60	50	50	40	50	50
Diazinon	100	100	100	100	100	100
Malathion	90	100	100	100	100	98
Control	0	10	10	10	0	6

TABLE XIII. -- Percent mortality of Blattella germanica after 24 hours when exposed to surfaces treated with insecticides, at high concentration.

Treatment	Percent mortality in replicate 1	2	3	4	5	Av. % mort.
Dieldrin	90	80	90	70	100	86
Chlordane	80	90	80	90	70	70
Heptachlor	90	90	80	70	80	70
DDT	10	10	20	40	30	22
Diazinon	90	100	100	100	100	98
Malathion	80	100	90	100	80	90
Control	0	0	0	10	0	2

TABLE XIV. -- Percent mortality of Blatella germanica after 48 hours when exposed to surfaces treated with insecticides, at high concentration.

Treatment	Percent mortality in replicate 1	2	3	4	5	Av. % mort.
Dieldrin	100	80	90	90	100	92
Chlordane	90	90	100	90	80	90
Heptachlor	100	90	90	90	80	90
DDT	60	40	40	50	70	52
Diazinon	100	100	100	100	100	100
Malathion	80	100	100	100	90	94
Control	20	10	0	10	0	8

TABLE XV. -- Percent mortality of Blattella germanica after 72 hours when exposed to surfaces treated with insecticides, at high concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	100	100	90	90	100	96
Chlordane	100	90	100	100	80	94
Heptachlor	100	100	100	100	90	98
DDT	70	50	60	60	70	62
Diazinon	100	100	100	100	100	100
Malathion	80	100	100	100	100	96
Control	20	10	0	10	10	10

TABLE XVI. -- Percent mortality of Blattella germanica after 24 hours when exposed to surfaces treated with insecticides, at low concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	40	40	40	60	50	46
Chlordane	50	60	40	40	50	48
Heptachlor	30	40	40	20	30	32
DDT	0	0	30	40	20	18
Diazinon	50	50	50	40	20	42
Malathion	50	50	20	60	60	48
Control	0	0	0	0	0	0

TABLE XVII. -- Percent mortality of Blattella germanica after 48 hours when exposed to surfaces treated with insecticides, at low concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	70	80	50	90	70	72
Chlordane	90	70	70	70	70	74
Heptachlor	70	70	80	60	70	70
DDT	60	30	50	40	30	42
Diazinon	100	90	90	100	90	94
Malathion	70	100	100	80	90	88
Control	20	0	0	10	0	6

TABLE XVIII. -- Percent mortality of Blattella germanica after 72 hours when exposed to surfaces treated with insecticides, at low concentration.

Treatment	Percent mortality in replicate					Av. % mort.
	1	2	3	4	5	
Dieldrin	90	100	80	90	100	92
Chlordane	100	80	90	100	70	88
Heptachlor	100	70	100	70	80	84
DDT	60	50	50	40	50	50
Diazinon	100	100	100	100	90	98
Malathion	80	100	100	80	100	92
Control	20	0	0	10	10	8