THREE DEODORIZED PETROLEUM OILS
AS INSECTICIDE CARRIERS

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By

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PREFACE

Due to newly developed residual insecticides, there has been a great change in insecticidal formulations recommended for the control of insects infesting dwellings, industrial establishments such as warehouses, dairies, restaurants, farm buildings, and the like. Several of the new insecticides are often dissolved in a petroleum base oil.

In an effort to develop an efficient base oil the Anderson-Prichard Oil Corporation, through the efforts of Mr. B. I. Scoggin and Dr. C. C. Allen, established a research fellowship with the Department of Entomology, Oklahoma Agricultural Experiment Station.

The writer wishes to express his appreciation to Professor F. A. Fenton, Head of the Department of Entomology, under whose direction this research was conducted for his assistance and untiring efforts; Professor D. E. Howell, of the Department of Entomology, for his help and suggestions; and Mr. J. A. Baker, student in the Department of Entomology, for his assistance in rearing the insects and in the insecticide experiments. Acknowledgement is also due Professor F. E. Whitehead, a member of the Thesis Committee, for his suggestions in the preparation of this thesis.

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INTRODUCTION

Prior to the advent of DDT, few contact insecticides remained effective for more than a few days, some even hours. Since the discovery of the insecticidal properties of DDT there have appeared certain other compounds that also remain effective over a period of weeks and even months.

The purpose of this research was to evaluate three deodorized petroleum oils as insecticide carriers[1] for space sprays and some of the residual insecticides. This was accomplished by laboratory tests at Stillwater, Oklahoma during the period of June 1946 to June 1947.

The house fly, *Musca domestica* (L.), was used exclusively as the test insect for three reasons:

(1) It is probably the most important household insect against which these insecticides are directed.

(2) It is relatively sensitive to various insecticides and therefore valuable as a biological indicator of a toxicant in a carrier.

(3) It is comparatively easy to rear and test under laboratory conditions.

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[1] Although the base oil is actually a solvent it is referred to here as a "carrier".

REVIEW OF LITERATURE

The first mention in literature of the use of a petroleum oil as an insecticide in this country was made by C. V. Riley (14) in his annual report for 1882. He described the use of kerosene for the control of scale insects on Florida citrus trees. He stated that crude petroleum was even more injurious to plants than kerosene. The injurious effects of kerosene and other petroleum oils apparently limited its use for some years. Then in 1911 Shafer (16) demonstrated by dissection the mode of action of a contact insecticide (pyrethrum in kerosene). He was the first to prove that "the weaker the surface tension of the fluid and the thinner the chitin with which it is in contact, the more rapid the penetration". This discovery led to research by Moore and Graham (8) who investigated the physical properties of contact insecticides. They concluded that "compounds with a viscosity as high or higher than castor oil spread so slowly that, in general, they may be classed as poor insecticides" and that "compounds more volatile than xylene evaporate too quickly for effective work". Their work corroborated that of Shafer when they wrote,"Volatility is an index of the ability of the compound to gain entrance into the insect, and is therefore closely correlated with toxicity". When they confined their work to various petroleum fractions in the kerosene range they found again that the low boiling point fractions are more toxic to insects. (7)

Shafer and Moore arrived at the same conclusion though they approached the problem from different angles.

Even though kerosene proved to be a good oil base for household sprays, there was a considerable variation in toxicity of marketed insecticides. In an effort to evaluate household sprays a method was developed by Peet and Grady in 1928 (10) and later revised by Peet (11). Murphy and Peet (9) then set up two requisites for an effective insecticide that are usually taken for granted, but seldom put into writing. They said an effective insecticide must "(1) penetrate to the vital parts of the insect, (2) be held in contact with the insect long enough to accomplish its end". Thinking the second property to be the more important, they thought a heavy oil (long film life) would be more effective. They tried petroleum solvents ranging from paint and varnish makers naphtha to a heavy stock spray base. The low viscosity solvents gave better results leading them to conclude that "the killing power of insecticidal materials can be materially increased if dissolved in oils of proper viscosity, i. e. low, viscosity".

This introduction so far has been to explain why the naphthas and kerosenes are used as bases for household insecticides in preference to those that have a slower rate of evaporation. Once a general range distillation was established the refineries began to produce odorless or deodorized petroleum oils for use in homes, hotels, restaurants, warehouses, etc. The usual kerosene fly spray base was objectionable because of its odor and taste, if sprayed on or near food. For years various perfumes were added to household sprays[2] but often they were just as objectionable.

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[2] To mask the odor of kerosene.

In 1926 Gray and de Ong (5) found that on plants "toxicity of the oils tested appeared to increase roughly in proportion of the amount of unsaturated compounds present". There followed a trend of using more highly refined oils to prevent plant injury that in turn led to the use of the same oils as bases for household insecticides. Since 1932 Ginsburg et al (4) had been experimenting with a "highly refined, low boiling petroleum distillate called Deo-Base" for the control of some greenhouse insects. Apparently there was some discussion of the possibility of that oil as a fly spray base at the annual meeting of the National Association of Insecticide and Disinfectant Manufacturers in December 1933, for there appeared in the January 1934 issue of Soap an advertisement for Deo-Base for use in a household spray. That is the nearest approximation of the first use of deodorized oils as bases for household insecticides. There seemed to be no definite date for the introduction of deodorized oils; rather there was a trend in that direction during the years 1926-1934.

As previously stated, the house fly was the test insect used for the experiments referred to in this thesis. Rearing procedures described by Richardson (13), Eagleson (3) and the Peet-Grady Method (1) were compared. The latter proved most satisfactory, and was used in rearing the flies tested.

DEODORIZED PETROLEUM OILS TESTED

The three deodorized petroleum oils tested during this research were developed as bases for different types of insecticidal use. Hereafter the term "Deo" will signify the deodorized product. Deo Apco 125 was developed to be used where a fast evaporating oil was desirable. Deo Apco 467 was intended as a base for most household sprays, since it has a fairly rapid rate of evaporation. The manufacturer states that these two oils are naphthas. Deo Apco 700 was intended for use as a livestock spray base and for residual sprays in and around barns. The specifications of these three oils as given by Scoggin, Steiner and Allen (15), are as follows:

	Deodorized Apco		
	125	467	700
I. B. P.	326	424	480
50%	353	442	568
Dry point	405	480	568
Final boiling point	- -	- -	700
Color	water white	water white	water white
Flash point--TCC	118	186	- -
Flash point--COC	- -	200	- -
Flash point--Pensky-Martens	- -	- -	230
Viscosity @ 100°F.	- -	- -	43
Pour point--Degrees F.	- -	- -	30
Odor quality	Neutral to water-like	non-residual (all)	
Odor intensity (Osmoscope)	2	1	1
Unsulfonated residue	- -	98	95

SPACE SPRAY TESTS

The standard Peet-Grady method was used to evaluate the three deodorized oils as carriers for space spray toxicants. Efforts to remove DDT deposits on wood or stainless steel surfaces were not successful, nor is there unanimity among entomologists as to the ability to remove a DDT deposit from the walls of a Peet-Grady chamber. It was the danger of a long period of contamination by DDT or some other toxicant that led to the division of the tests into two parts, namely space sprays and residual.

Equipment

The equipment used for the Peet-Grady tests has been previously described (11). Tests showed that the spray was not equally distributed inside the chamber (Table 1).

In an attempt to reduce the number of flies needed per test, and time and labor involved in each Peet-Grady test, Hoskins' settling mist apparatus (12) and Eagleson's spray tunnel (2) were used.

The same de Vilbiss atomizer used for the Peet-Grady tests was used in the Eagleson and Hoskins apparatus at the same air pressure, i.e. 12.5 lb. per sq. in.

Materials

The toxicants used in the space spray tests were "Lethane 384", pyrethrum, and "Thanite".

Lethane 384 is described by Rohm and Haas as "a solution of beta butoxy beta thiocyano diethyl ether standardized at 50% by volume with petroleum distillate".

The pyrethrum used was obtained from the Anderson-Prichard Company and was labeled "Pyrethrum extract (odorless) 20%". The pyrethrin content was unknown.

Thanite as described by Hercules Powder Company "is composed of at least 82% isobornyl thiocyanoacetate, and 18% other active terpenes, containing no diluents, and is soluble in all proportions in base oils".

Methods

There are several differences between the Peet-Grady method and the others employed. In the Peet-Grady test about 500 flies are used per test, and these are liberated in the test chamber. Approximately 100 or less flies are necessary for each Eagleson or Hoskins test, and these are confined in a wire screen cylinder. The Peet-Grady test gives more accurate knockdown data due to some unknown cause. The consumer using a space spray is interested as much in immediate knockdown as eventual mortality. The Peet-Grady procedure measures this important factor after 10 minutes exposure to the insecticide. Mortality is computed 24± 1 hour later. In any group of flies there is some variation. Because of this it is necessary to evaluate space sprays with a standard insecticide known as the Official Test Insecticide (O.T.I.). The main difficulty encountered was that the mortality of certain fly cultures exposed to the O.T.I. was often outside the established tolerance limits, namely 30 to 55 per cent.

The "rating" of an insecticide tested by the Peet-Grady method is the difference in average mortality between that produced by the O.T.I. and the "unknown" insecticide (in this case, the oil carriers, since the toxicant remains constant).

An insecticide is graded according to its rating as follows:

Grade B is a rating of - 5 to +5.

Grade A is a rating of +5 to +15.

Grade AA is a rating of +16 or better.

Results

The data on Peet-Grady tests are summarized in Table 2.

Lethane. - This chemical consistently produced the highest knockdown in all three oils. Even 2 per cent produced knockdowns of 97 per cent or better. Deo Apco 125 appeared to be the best base oil for Lethane.

Pyrethrum. - This caused a slightly lower knockdown average than Lethane, but at 3 per cent in Deo Apco 125 and 467 pyrethrum had higher ratings (6 and 13 points respectively). A 3 per cent solution of pyrethrum in Deo Apco 125 or 467 was a AA insecticide.

Thanite. - This chemical was disappointing in its performance. In spite of the AA grade for 5 per cent in Deo Apco 467 the flies were knocked down slowly, making each test quite laborious. Deo Apco 467 was a better base oil than the figures indicate.

Among some trial tests with the Hoskins settling mist apparatus, the three oils alone were used in one series. The results are shown in Table 3. Though Deo Apco 125 is relatively non-toxic, Deo Apco 467 and 700 are quite evidently toxic. Two tests with the Eagleson spray tunnel using straight Deo Apco 125 produced no knockdown, but did cause 15 and 11 per cent mortality. The O.T.I. used as a check on the flies caused 81 and 50 per cent mortality.

RESIDUAL TESTS

Equipment

The equipment for residual tests was quite simple, merely a triangular wooden box treated with a measured amount of insecticide. A glass cover kept the flies enclosed and enabled the observer to check mortality or knockdown at any time. The component parts of a test box are shown in Plate 1.

The test boxes were described to the writer by Dr. H. A. Waters of Ohio State University and Sherwin-Williams Company. Dr. Howell designed a similar test box with an inside area of 100 square inches. A new method of introducing flies into the boxes was developed by Dr. Howell. This proved much easier and faster. This method is shown in Plate 2. From a stock cage a glass funnel is filled with as many flies as possible. A metal slide over the wide mouth of the funnel holds the flies until they can be released into the test boxes, which is accomplished by sliding back the glass cover of the box enough to leave an opening of about ½ inch. The edge of the metal slide on the funnel is placed against the edge of the glass at this opening, and then withdrawn enough to allow one fly at a time to enter the test box. Ten flies can be counted quickly and accurately.

Residual toxicity was determined by spraying or painting the wooden test boxes. The three sides were hinged, allowing the sides to drop flat. For one series of tests the boxes were hung on the south side of the laboratory building to determine the effects of weathering. The remaining series were stored in the laboratory.

Materials

DDT, Velsicol 1068[3] and benzene hexachloride were the residual toxicants studied.

The DDT was technical grade obtained from the Pennsylvania Salt Company through the Anderson-Prichard Oil Corporation. The p, p'isomer content was unknown. It dissolved readily at 5 per cent in all but Deo Apco 700. Some difficulty was noticed in the latter, but solution was accomplished after several hours.

The sample of 1068 was put up as a 20 per cent solution (Technical grade) by the Velsicol Corporation. It dissolved readily in all three deodorized oils.

The gamma isomer of benzene hexachloride is the toxic ingredient. The sample tested was produced by Du Pont Corporation as a 30 per cent gamma isomer concentrate. It resembled brown sugar in appearance, but had a distinct disagreeable musty odor, a limiting factor in its use as a household insecticide. The crystals did not dissolve completely in any of the oils at a gamma isomer concentration of 0.5 per cent.

Methods

To eliminate some variations inherent with most biological tests, ten flies were used per box, two boxes used per test and readings were taken when there was 50 and 100 per cent knockdown. "Knockdown" in

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[3] Other trade names are: Octa-Klor and Dowchlor. However the name "Chlordane" has been recently approved by the Committee on Insecticide Nomenclature of the American Association of Economic Entomologists.

in this case means a fly on its back unable to get up. The time to reach 50 per cent knockdown was used to evaluate different treatments. It was thought that ten flies were sufficient to obtain fairly accurate performance data, provided there were sufficient replications.

The boxes in the first two series were treated by spraying them with 10 ml. of DDT and Velsicol 1068. The inner sides and bottom of each box were treated. Using this amount of spray means that at 5 per cent concentration there would be 5 mg. per square inch. However, there was some loss of the spray in the air and run off. To correct this fault, subsequent treatments were made by painting 4 ml. of solution on each box (Plate 3.) leaving a deposit of 2 mg. per square inch. At the time of treatment there was a noticeable variation among the boxes as to the absorption or penetration of the oil solution. All concentrations of DDT and benzene hexachloride were dissolved on a weight per volume basis. Velsicol 1068, already dissolved at a 20 per cent concentration, was diluted with the appropriate oil carrier.

Each test consisted of two replicates, except where otherwise noted. Thus the "time to reach 50 per cent knockdown" for a particular concentration is an average of the time for the two replicates of that concentration. The tests of the painted surface had four replicates.

The duration of toxicity was measured by introducing flies at regular intervals from one week to one month apart. The comparative toxicity of different materials and of various concentrations of the same material were measured by comparisons made of knockdown in concurrent tests.

The interior surface of the test boxes was unpainted except for one series of tests made on a painted surface (Table 4). There were two coats of semi-gloss white enamel[4] over a gray prime coat.

The average temperature during each test period is included with the tables, because toxicity seems to vary somewhat with the temperature. Relative humidity was also recorded, but is not included.

Results with DDT

Deo Apco 125 (Table 5) - The toxicity of 5 and 3 per cent was very nearly the same throughout. Even 5 and 6 months after treatment the 3 per cent appears to be a little better. This is probably due to experimental error. Concentrations of 1, 0.6, 0.2 per cent were toxic for a much shorter time. Data for 100 per cent knockdown though not given in this thesis showed 5 per cent to be more toxic than 3 per cent after 60 days.

Deo Apco 467 (Table 6) - Though the 5 and 3 per cent concentrations were almost equally toxic, there was more difference than with Deo Apco 125. The 1 per cent at times seemed less toxic than 0.6 per cent, but again this was probably due to experimental error.

Deo Apco 125 and 467 on painted wood (Table 4) - An oil solution of DDT applied to painted wood seems to be less toxic than when applied to unpainted wood. A 5 per cent concentration remained toxic longer than 1 per cent. Deo Apco 125 was a more effective carrier than Deo Apco 467.

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[4] "Kyanize" manufactured by the Boston Varnish Company.

Deo Apco 700 (Table 7) - This oil, though leaving a longer lasting film, is inferior to both Deo Apco 125 and 467. This was not as one might expect, but later information gathered by Howell (6) supports the results obtained with these three oils.

Comparison of the three deodorized oils as carriers for DDT

Table 8 contains a rearrangement of data found in Tables 5, 6, and 7. By direct comparison for a given date it is possible to evaluate the three oils as carriers for DDT. The 5 and 3 per cent concentrations were chosen because they are the most likely concentrations to be marketed. At first glance it is easy to see that Deo Apco 700 is inferior to the other two oils. There is not enough difference between Deo Apco 125 and 467 to say definitely which is the better carrier. What differences there are could very well be those between the boxes themselves.

Results with Velsicol 1068

Deo Apco 125 (Table 9) - There seems to be no marked difference between 5 and 3 per cent as there is between 3 and 1 per cent. Unlike DDT even the lower concentrations remained toxic over the three and one-half month period of the test. It is entirely possible that the lower concentrations of DDT might have been effective longer if they had been tested at lower temperatures.

Deo Apco 700 (Table 10) - There is more apparent difference between the 5 and 3 per cent than with Deo Apco 125. The lower concentrations are noticeably weaker.

Results with benzene hexachloride

Deo Apco 125, 467 and 700 (Tables 11, 12, and 13) - A comparison of the three deodorized oils as carriers for benzene hexachloride shows that toxicity decreased as the gamma isomer content was decreased. Deo Apco 125 seems to be the best at 0.5 per cent, about the same as Deo Apco 700 at 0.3 per cent, but at 0.1 per cent and lower Deo Apco 700 seems to hold toxicity a little better.

Effects of weather on 5 per cent DDT and 0.5 per cent benzene hexachloride (Table 14)

One day after treatment benzene hexachloride was as toxic if not more so than DDT, but when both were exposed to winter weathering the DDT deposits lost their toxicity noticeably slower than benzene hexachloride. DDT dissolved in Deo Apco 125 withstood weathering better than when dissolved in the other two oils. Deo Apco 125 appears to be slightly better than Deo Apco 700 as a carrier for benzene hexachloride. At each observation, except the last on Feb. 21, Deo Apco 125 reached the 50 per cent knockdown point before Deo Apco 700.

DISCUSSION

Since the Peet-Grady method was introduced there have been criticisms, modifications, and other testing methods proposed. In spite of this it has remained the official method of evaluating household insecticides since its adoption in 1932 by the National Association of Insecticide and Disinfectant Manufacturers. Table 1 clearly indicates the unequal distribution of spray droplets within the chamber. This fault plus the large number of flies necessary for each test led to trials of the Hoskins apparatus and Eagleson spray tunnel. The O.T.I. was used in the attempts to approximate the Peet-Grady results. The Hoskins apparatus proved unsatisfactory and it was not until June 1947 that results obtained by the Eagleson tunnel approximated those obtained in the Peet-Grady chamber. Eagleson's spray tunnel can be used to evaluate residual insecticides incorporated with space sprays. DDT deposits can be removed by flaming the screen cylinders.

Deo Apco 700 was tested with these non-residual toxicants, but it was not intended for, and is inadequate as a household spray base.

Temperature data were given in Tables 3 to 13 to show the effects of temperature on the speed of knockdown of the residual insecticides tested. With an increase of temperature there was a general decrease of toxicity of DDT. Since there were times when all three toxicants were being tested under the same conditions, the temperature effect was more noticeable to the observers in the laboratory than can be indicated in the tables of this thesis.

The temperatures of the testing room were one source of variation of the knockdown time. Other variables were differences in fly susceptibility (demonstrated in the Peet-Grady O.T.I. mortalities) and differences in penetration of the oil when applied to different kinds of wood of which the boxes were made. The variations just mentioned are an attempt to explain why two boxes treated alike, stored alike, and tested alike have apparent differences in toxicities. One thing that these variations prove is that two replicates are not enough for this type of test. The tests of DDT on painted wood had four replicates and even there a wide range was encountered.

CONCLUSIONS

Lethane consistently produced the best knockdown in all three oils. Deo Apco 125 appeared to be the best carrier for Lethane. Lethane and pyrethrum at 3 per cent strength in Deo Apco 125 are AA insecticides.

The toxicity of a residual deposit depends on the solvent, but mainly on the per cent of toxicant used. It is natural to expect, within certain limits, that the more insecticide that is applied the longer it will last. DDT is the best residual insecticide of those tested with the three deodorized oils. In addition its oil solutions are odorless, nearly tasteless and have not been observed to stain cloth or paper. Deo Apco 125 was the superior base oil for DDT, Velsicol 1068, and benzene hexachloride. To be effective in Deo Apco 125, DDT or Velsicol 1068 should be used at a strength of 3 per cent, preferably 5 per cent. If a knockdown agent, such as Lethane or pyrethrum, is added it should not be less than 3 per cent.

It is fortunate for the insecticide manufacturer and consumer that the same oil carrier, whether Deo Apco 125 or some other of like quality, can be used for space sprays and residual insecticides.

SUMMARY

To evaluate three deodorized oils as insecticide carriers laboratory tests were conducted at Stillwater, Oklahoma, from June 1946 to June 1947. Previous work had shown that low viscosity solvents were better carriers for space sprays when evaluated by the Peet-Grady method. Results of this research indicated that the lowest viscosity oil of the three, Deo Apco 125, was the best carrier for such knockdown agents as Lethane and pyrethrum. Residual insecticides dissolved in the three oils were tested by painting the inside of triangular wooden boxes, introducing ten house flies, then recording the time necessary to knock down 50per cent. By testing space spray insecticides in conjunction with residual insecticides it was possible to show that the same type of base oil (low viscosity) was the best carrier for both.

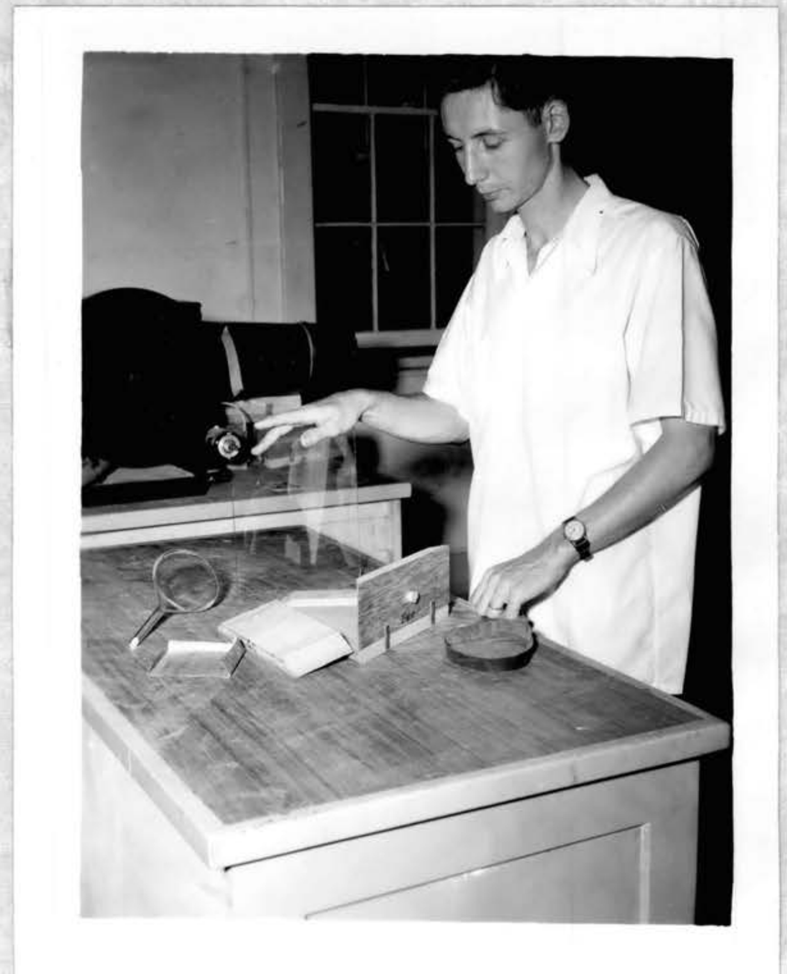

Plate 1 - A test box with glass cover and rubber band (to hold sides tightly together). Glass funnel and metal slide are also shown.

Plate 2 - Method of introducing flies into test boxes.

Plate 3 - Method of painting 4 ml. of oil solution on a test box.

Table 1. Droplet dispersion test, Deo Apco 467 with 3% Lethane, Peet-Grady Chamber, Stillwater, Oklahoma. October 31, 1946.

Slide No.	No. droplets counted per 1 square inch	Location of slides	Totals per location
1	22	centered 1'	
2	11	from edge of	97
3	8	ceiling on	
4	56	each side	
5	6	centered 1'	
6	248	from top	303
7	42	on each	
8	7	wall	
9	28	centered 3'	
10	0	from floor	547
11	519	on each	
12	0	wall	
13	2	centered 1'	
14	1400	from floor	1467
15	0	on each	
16	65	wall	
17	2320	center of	
18	---	chamber	9280*
19	---	floor	
20	---		

* Estimated.

Table 2. Summary of Peet-Grady Tests with Deo Apco Oils, Stillwater, Oklahoma. 1946-47.

Toxicant	Deo Apco Oil	Avg. % K.D.	Mortalities	Avg. Mortality	O. T. I. Mortalities	Avg.O.T.I. Mortality	Rating	Grade
3% Lethane	125	99	95, 82	89	53, 55	54	+35	AA
	467	99	64, 71	68	53, 55	54	+14	A
	700	98	73, 74	74	53	53	+21	AA
2% Lethane	125	100	48, 63, 49	53	46, 52, 53	50	+ 3	B
	467	99	51, 32	42	43, 53	48	- 6	- -
	700	97	21, 25	23	54, 43	49	-26	- -
3% Pyrethrum	125	92	91, 83, 80, 89	86	56, 53, 31, 39	45	+41	AA
	467	96	66, 89, 67	74	56, 53, 31	47	+27	AA
	700	80	64, 34	49	56, 31	44	+ 5	B
2% Pyrethrum	125	62	72, 42, 62, 59	59	52, 45, 45, 39	45	+14	A
	467	84	37, 42, 45	41	45, 45	45	- 4	B
5% Thanite	125	65	49, 61, 70, 73	63	57, 50	53	+10	A
	467	94	80, 80, 88	83	39, 47	43	+40	AA
3% Thanite	125	19	30, 12, 7	16	53, 45, 47	48	-32	- -
	467	67	40, 29	35	53, 45	49	-14	- -
	700	53	36, 30	33	53, 45	49	-16	- -

Table 3. Toxicity of Deo Apco 125, 467, 700 to house flies exposed to a settling mist. Stillwater, Oklahoma 1946.

Deo Apco Oil	No. flies	No. dead	Per cent killed
125	155	3	1.9
467	101	101	100
700	198	198	100

Table 4. Toxicity of DDT in Deo Apco 125 and 467 to house flies when applied to a painted surface. Stillwater, Oklahoma 1946-47.

Days after Treatment	Minutes to reach 50 per cent knockdown				
	Deo Apco 125		Deo Apco 467		Temp. °F
	5%	1%	5%	1%	
1	66	228	46	384*	80
8	59	513	56	570*	80
35	113	524	222	541	78
63	140	572	574	600	77

* 50 per cent knockdown was not reached at this time in one box.

Table 5. Toxicity as measured by 50 per cent knockdown of house flies of DDT in Deo Apco 125. Stillwater, Oklahoma. 1946-47.

Date		Minutes to reach 50% K.D. at different percents					Temp. °F.
		5.0%	3.0%	1.0%	0.6%	0.2%	
Sept.	14	13	16.0	30.0	31.5	40	80
	21	21.5	20.5	64.5	114.5	128.0	78
	27	31	32	115.5	153.5	249 [1]	81
Oct.	5	48	42.5	245	- -	480 [1]	76
	12	35	37	- -	- -	- -	80
	14	61	65	114.5	- -	- -	80
	19	78	67	149.5	Not tested		No record
	26	57.5	75.5	134.0	Discont.	314 [1]	68
Nov.	2	114	100	232		572 [1]	78
	9	103.5	103	270		- -	82
	16	101.5	147.5	373.5		569 [1]	81
	23	168.5	138	320 [1]		530 [1]	81
	30	133.5	179	466		433 [1]	81
Dec.	31	80	157.5				74
Jan.	30	116.5	120				67
Feb.	21	123.5	111				78
Mar.	21	177	103				77

[1] Test not replicated.

Table 6. Toxicity as measured by 50 per cent knockdown of house flies of DDT in Deo Apco 467. Stillwater, Oklahoma. 1946-47.

Date		Minutes to reach 50% K.D. at different percents					Temp. °F.
		5.0%	3.0%	1.0%	0.6%	0.2%	
Sept.	14	- -	- -	- -	- -	- -	
	21	20	32.5	45.5	75	299.5	78
	28	35.5	135.5	324.5	299	360	81
Oct.	5	48.5	65	109.5	91.5	236 [1]	76
	14	44.5	45	176	103.5	556 [1]	80
	19	34	39	112	67	361 [1]	no record
	26	60	52 [1]	206.5	92	323 [1]	68
Nov.	2	94	112.5	236	253	506 [1]	78
	9	59.5	90	207	199	366 [1]	82
	16	101.5	112	348	377	747 [1]	81
	23	182.5	167	540 [1]	323.5	- - [1]	81
	30	143	164.5	355	391	668	81
Dec.	31	147.5	180				74
Jan.	30	107	174.5				67
Feb.	21	159	195				78
Mar.	21	153	174				77

Table 7. Toxicity as measured by 50 per cent knockdown of house flies of DDT in Deo Apco 700. Stillwater, Oklahoma. 1946-47.

Date		Minutes to reach 50% K.D. at different percents					Temp. °F.
		5.0%	3.0%	1.0%	0.6%	0.2%	
Sept.	14	25.5	38.0	87.0	119.5	376.0	80
	21	34.5	88.5	196.0	249.0	- -	78
	28	53.5	227.5	- -	- -	- -	81
Oct.	5	96.5	183.0	476.0[1]	- -	not tested	76
	14	75.5	242.5	543.0	discontinued		80
	19	100.5	345.5	- -	- -	- -	no record
	26	72.5	156.0	399.0	- -	- -	68
Nov.	2	104.0	158.0	418.5	- -	- -	78
	9	187.0	278.0	499.5	- -	- -	82
	16	208.0	414.5	588.0	- -	- -	81
	23	445.5	375.5	476.5	- -	- -	81
	30	231.0	296.0	547.5	- -	- -	81
Dec.	31	326	487				74

[1] Test not replicated.

Table 8. Comparison of three oils as carriers of DDT.

Date		Minutes to reach 50 per cent knockdown					
		5 per cent DDT			3 per cent DDT		
	Deo Apco	125	467	700	125	467	700
Sept.	14	13		26	16		38
	21	22	20	35	21	33	89
	27	31	36	54	32	136	228
Oct.	5	48	49	97	43	65	183
	14	61	45	76	65	45	243
	19	78	34	101	67	39	346
	26	58	60	73	76	52	156
Nov.	2	114	94	104	100	113	158
	9	104	60	187	103	90	278
	16	102	102	208	148	112	415
	23	169	183	446	138	167	376
	30	134	143	231	179	164	296
Dec.	31	80	148	326	158	180	487
Jan.	30	117	107		120	175	
Feb.	21	124	159		111	195	
Mar.	21	177	153		103	174	

Table 9. Toxicity of 1068 in Deo Apco 125 as measured by 50 per cent knockdown of house flies, Stillwater, Oklahoma. 1946. (10 ml. sprayed on each box)

Date		Minutes to reach 50 per cent knockdown at different per cents					
		5%	3%	1%	0.6%	0.2%	Av.Temp.°F
Sept.	13	40	36	46	41	45	80
	21	128	147	172	181	234	78
	27	115	121	231	150	240[1]	81
Oct.	5	129	156	202	272	271[1]	76
	14	102	108	192	149	249[1]	80
	19	105	107	153	177	265[1]	no record
	26	68	77[1]	121	114	177[1]	68
Nov.	2	198	185[1]	284	349	384[1]	78
	9	115	121[1]	218	260	---[3]	82
	16	136	158	280	307	456	81
	23	175	189	297	290	476	81
	30	133	156	271	321	437	81
Dec.	31	318	296	484	495	over 610[2]	74

[1] Test not replicated.
[2] 50 per cent knockdown not reached in one box.
[3] 50 per cent knockdown not reached in either box.

Table 10. Toxicity of 1068 in Deo Apco 700 as measured by 50 per cent knockdown of house flies, Stillwater, Oklahoma. 1946. (10 ml. sprayed on each box)

Date		Minutes to reach 50 per cent knockdown at different per cents					
		5%	3%	1%	0.6%	0.2%	Av.Temp.°F
Sept.	13	76	83	125	149	178[1]	80
	21	223	201	377	430	- -	78
	27	154	170	317	363	- -	81
Oct.	5	202	285	393	465	- -	76
	14	128	216	295	516	- -	80
	19	153	203	332	369	- -	no record
	26	133	120	178	174	- -	68
Nov.	2	208	260	407	365[1]	- -	78
	9	164	185	282	275	- -	82
	16	233	314	401	486	- -	81
	23	248	304	415	547	- -	81
	30	186	279	394	437	- -	81
Dec.	31	256	379	542[1]	534	- -	74

Table 11. Toxicity of benzene hexachloride in Deo Apco 125 as measured by 50 per cent knockdown of house flies, Stillwater, Oklahoma. 1946-47.

Date		Minutes to reach 50 per cent knockdown at different concentrations of the gamma isomer					
		0.5%	0.3%	0.1%	0.06	0.02	Av.Temp.°F
Dec.	11	20	49	53	88	160	76
	21	38	47	70	74	345	85
	28	64	102	152	244	489	77
Jan.	4	96	124	182	253	484	79
	11	not tested	108	282	not tested	not tested	79
	18	65	153	259	141	296	80
	25	71	112	288	249	489	80
Feb.	21	82	133	219	203	332	78
Mar.	21	106	160	165	248	544	77

[1] 50 per cent knockdown not reached in one box.

Table 12. Toxicity of benzene hexachloride in Deo Apco 467 as measured by 50 per cent knockdown of house flies, Stillwater, Oklahoma. 1946-47.

Date		Minutes to reach 50 per cent knockdown at different concentrations of gamma isomer					
		0.5%	0.3%	0.1%	0.06%	0.02%	Av. Temp. °F
Dec.	11	74	51	98	167	178	76
	21	54	59	97	123	180	85
	28	117	110	216	371	500	77
Jan.	4	119	117	185	462	384	79
	11	not tested	151	303	not tested	not tested	79
	18	138	287	333	333	223	80
	25	139	164	337	407	332	80
Feb.	21	110	161	416	406	285	78
Mar.	21	153	296	492	242	314	77

Table 13. Toxicity of benzene hexachloride in Deo Apco 700 as measured by 50 per cent knockdown of house flies, Stillwater, Oklahoma. 1946-47.

Date		Minutes to reach 50 per cent knockdown at different concentrations of gamma isomer					
		0.5%	0.3%	0.1%	0.06%	0.02%	Av. Temp. °F
Dec.	11	58	58	99	122	167	76
	21	44	81	87	117	143	85
	28	101	133	196	272	198	77
Jan.	4	84	125	158	205	492	79
	11	not tested	106	189	not tested	not tested	79
	18	87	161	195	408	600[1]	80
	25	117	104	258	457	600[1]	80
Feb.	21	120	97	235	- -	- -	78
Mar.	21	116	150	196	- -	- -	77

[1] 50 per cent knockdown not reached in one box.

Table 14. Comparative toxicities of 5% DDT and 0.5% gamma isomer of benzene hexachloride to house flies when treated surfaces were exposed to weathering. Stillwater, Oklahoma. 1946-47.

Date		Minutes to reach 50 per cent knockdown						Av.
		Deo Apco 125		Deo Apco 467		Deo Apco 700		Temp.
		DDT	B.H.	DDT	B.H.	DDT	B.H.	°F
Dec.	11	42	42	62	52	67	44	76
	21	68	88	45	93	75	101	85
	28	70	143	52	134	133	224	77
Jan.	4	98	130	82	272	105	157	79
	18	106	134	93	348	101	233	80
	25	124	241	106	276	140	301	80
Feb.	21	118	350	150	524	220	324	78
Mar.	21	179	not tested	278	not tested	290	not tested	77

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