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The Secretary of the Expert Committee on Malaria
has the honour to communicate hereunder
the following note:

THE FATE OF DDT SPRAYED ON MUD WALLS OF HOUSES
IN VENEZUELA¹

(Preliminary note)

by

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One of the difficulties found, when the nation-wide campaign against malaria with DDT indoors residual spraying was organized in 1945, was the adequate supervision of the spraying squads. This was not so acute during the first years when the squads worked in the most populated areas, as they were found easily by the inspector. Surprise visits were then possible to see the men working. The men's performance while spraying and the specks left by water suspensions, were a guide to the quality of the work. As soon as the squads began to spray the low-populated rural areas, where surprise visits were out of question, adequate supervision became difficult. To solve this problem, and to evaluate in figures the quality of spraying, a method was

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developed to examine large quantities of wall scrapings in order to measure the quantity of DDT present. In this way it was possible to be sure of what was happening in the field.

Wall scrapings were collected from the upper, middle and lower portions of walls, following a diagonal line, so that samples from two or three spraying swaths were obtained. Our men spray a wall following a vertical swath, from the upper portion of the wall to the lower one, and from this to the upper portion. The scrapings were acquired from one square of five centimetres side, of a depth of one to two millimetres. Most of these scrapings were made during the 30 days following the spraying. Some others were made at different times during the six months of the spraying cycle, so that it was possible to get a general idea of what was happening to the DDT put on the walls.

Since 1949 houses of the malaria zone of Venezuela are sprayed every six months. The theoretical amount of DDT deposited has been two grammes per square metre. This amount is obtained when 2.5 per cent suspensions of wetttable powders are sprayed with a Dobbins 8055 nozzle, or when 5 per cent emulsions or solutions are sprayed with a Spraying System 8002 nozzle. By wearing down these nozzles deposit larger amounts, so that periodical checkings are necessary. As many of the sprayed houses are of mud walls, a larger proportion of the insecticide used has been in the form of suspensions.

The results presented, of tests to determine the amount of DDT deposited on the walls, come from mud-wall houses from practically every region of the country. In the coastal region some salt is found in the mud. In the Llanos region red clay is a frequent constituent of the mud. Some soils have also a good amount of organic content. Some of the walls were without paint, and some others with some kind of paint, particularly lime wash. The number of samples which have been examined is probably one of the largest made in field work, and should give a good cross-view of actual conditions.

Results of Field Tests

The amount of DDT per square metre sprayed on a wall is not uniform. This is mostly due to: (a) differences of speed in the work, and (b) different concentration of insecticide in the sprayed swath. Table 2 shows that there is more DDT in the

upper portion of walls than in the middle and lower ones, which should be the result of slowing down when the worker reaches the upper levels. The nozzles used produce a fan-shaped spray which is elliptic in section, with the major axis of one metre. Thus, there is not a uniform amount of DDT deposit throughout the spraying swath, a higher concentration of the insecticide being present in the central part. This is shown by Table 3. Here, however, the lower portion of the spraying swath had more DDT than the upper one, which was probably due to the fact that the technician who did the spraying did not follow the same rhythm used by field workers. Therefore, it should be expected to find, in carefully sprayed walls, a good deal of difference in the collected scrapings for chemical analysis. This is shown by Table 4, where are found data of the distribution of DDT determinations from samples taken during a spraying cycle to walls of the same houses sprayed for the first time.

Table 1 and Figure 1 show DDT determinations made every month after spraying, in three groups of houses: (a) those which received from one to five sprayings, (b) those which had six to ten sprayings, and (c) those with eleven to fifteen sprayings. The two following facts are demonstrated by this Table:

- (1) There seems to be a trend of accumulation of DDT after the first five sprayings, but this accumulation does not increase after reaching a level of about three grammes per square metre.
- (2) There is a sudden decrease of DDT after the first 30 days of the spraying, representing a loss of generally not more than one gramme per square metre, a decrease which ceases and remains at about the same level during the following five months.

Results of Laboratory Tests

In 1950 some laboratory tests were made in order to investigate the possible decomposition of DDT or p.p'-DDT when mixed with earth used in mud employed for building walls. As HCl is one of the decomposition products of DDT, a potentiometric determination of pH was used as measurement of such decomposition. In test tubes maintained at 125°C. were placed 0.5 gm of DDT, or of p.p'-DDT, or

of mixtures of 0.5 gm of these insecticides and 0.1 gm of earth. Through the insecticides or the mixtures was slowly passed a current of humidified air after elimination of CO^2 . This air with the products of decomposition was liberated in a beaker with 20 cc of distilled water. With a potentiometre pH measurements of this water were made every two hours. The water was changed after every measurement. Results of these tests are presented in Table 5 and Figure 2.

In the measurements of the earth it is observed that pH remained very constant during the whole time of the experiment, with the exception of the readings at four and twelve hours, when rises of 0.8 and 0.5 were noticed. The curve of readings of the experiment with technical DDT was not so smooth, and two marked drops were found at four and ten hours, that is, just the reverse of what happened to the other curve. The third curve, corresponding to the mixture of technical DDT and earth, showed two marked drops at four and twelve hours, which may be related to the variations found in the curves mentioned above. After the four-hour drop this curve went back to its primitive level, but after the twelve-hour drop the increase was smaller and the rise, although slower, seems to be more constant. These drops are a sign of a sudden liberation of HCl, which appears to decrease with time. This production of HCl shows the decomposition suffered by DDT in presence of earth, which seems to be an enlargement of what happened to the insecticide when it was heated alone.

When p.p'-DDT was heated alone the drop observed at six hours was a very small one, and at twelve hours there was a rise, just the reverse of what was found in the experiment with technical DDT. In the mixture p.p'-DDT and earth, a great drop was observed at four hours, followed by a slow but constant rise. Decomposition suffered by p.p'-DDT mixed with earth was more intense but lasted a shorter time than in the case of DDT and earth.

These experiments may indicate that technical DDT and p.p'-DDT mixed with earth suffer a decomposition which is very quick at the beginning and much slower later, which might even disappear with time.

Discussion

Results of field tests presented in Table 1 show two problems which require an explanation: (a) the sudden drop of the amount of DDT after the first 30 days of the spraying, and (b) the low accumulation of the insecticide with repeated spraying in spite of the small loss observed during the six months of the cycle.

When a wettable powder DDT suspension is sprayed on a mud wall, the water is absorbed into the mud and most of the solids remain on the surface. There should be, however, a certain number of fine particles which penetrate into the mud and fill the spaces left by clay grains. With time these spaces may become clogged with such particles and their sorption be reduced. The non-sorbed particles, both of insecticide and inert materials, remaining on the surface, are exposed to physical agents.

If results of laboratory tests are a reflection of what happens in the field, the rapid loss of DDT the first days after spraying may be due to quick decomposition of the insecticide during its first time of contact with mud. After this preliminary decomposition the process decreases or ceases, and the undecomposed DDT sorbed into the mud remains for the rest of the spraying cycle.

With repeated spraying decomposed DDT will be replaced until decomposition entirely stops and no more sorption is produced as all available spaces in the clay of the outer layers of the mud wall will be clogged with previously sorbed material. Presence of this stable DDT may explain the accumulation observed after the first five sprayings. The non-sorbed portion of the water suspension remaining on the wall surface might be easily lost on account of different conditions, such as wind, cleaning of walls, etc.

If this is what actually happens, the action of DDT will be very powerful the first days after spraying, as a large quantity is present on the wall surface. Later, as the superficial DDT is lost, the outer particles of the sorbed portion will be the only active ones, and they might be responsible for the interruption of malaria transmission during most part of the spraying cycle. This will possibly be helped by the fact that a certain degree of erosion seems to be continuously occurring in mud walls, which are generally soft and dusty.

As the number of samples collected from sprayed houses has been large, 13,247 as shown in Table 1, the conclusion reached, that DDT remains on mud walls during the whole spraying cycle, should be a safe one. Biological confirmation of this fact is demonstrated by Table 6. In the Llanos region, where red clay soils are frequently used in the mud, the most abundant house haunting anopheline after the reduction and eradication of A. darlingi has been A. albitarsis. In four states of this area, in localities where for one reason or another some houses were left unsprayed, mosquito captures gave the results presented in Table 6. It may be observed in this Table that unsprayed houses have higher indices of infestation (number of captures with A. albitarsis in 100 house captures) and density (number of mosquitos in 100 house captures) than sprayed houses. This difference remained constant during the whole spraying cycle, an indication that DDT was effective all that time. A moderate increase in the index of density was observed, however, in the last four months of the cycle, which may be taken as a sign of the reduction of the amount of DDT found in wall scrapings in those months.

Summary

The determination of DDT in 13,247 scrapings from mud walls of houses from different regions of the malaria zone of Venezuela has shown that:

- (1) There is a trend of accumulation of DDT after the first sprayings, but this accumulation does not increase after reaching a level of about three grammes per square metre.
- (2) There is a sudden decrease of DDT after the first 30 days of the spraying, representing a loss of generally not more than one gramme per square metre, a decrease which remains at about the same level during the following five months.
- (3) Due mostly to difference in the speed of the work while spraying at different levels of walls and to the elliptic section of fan-shaped spray nozzles there is a normal variation of DDT contents from wall scrapings. The range of this variation is from below 0.5 grammes to above 6.0 grammes per square metre. This variation deserves careful consideration in studies of this type.

(4) DDT sprayed on mud walls at an average dose of one gramme per square metre, although slightly lost after six months, keeps its activity during all this time as shown by a reduction in the number of anophelines present in sprayed houses when compared with unsprayed houses of the same locality.

(5) All this indicates that under conditions found in Venezuela DDT may be slightly decomposed by the mud used for building materials in many houses of rural communities, or lost on account of physical agents, but the decrease suffered by the insecticide due to these factors is not large enough to greatly impair its effect on malaria transmission.

(6) In large rural areas of Venezuela where malaria has been mainly transmitted by A. albimanus and A. darlingi, and in smaller sections where A. albitarsis and A. pseudopunctipennis are the incriminated vectors, DDT spraying of mud wall houses has proved an efficient method of malaria control, and eradication of the disease has been obtained in large districts so protected.

Table 1

Amount of DDT in walls of houses which have received different number of sprayings

Days after spraying	1-5 sprayings		6-10 sprayings		11-15 sprayings	
	Number of samples	Gms per sq. mt.	Number of samples	Gms per sq. mt.	Number of samples	Gms per sq. mt.
1-30	2,748	1.9	3,162	3.1	1,159	3.0
31-60	765	1.3	993	2.1	414	1.7
61-90	368	1.9	500	1.9	319	1.8
91-120	439	1.4	426	1.7	300	1.6
121-150	347	1.5	523	1.9	240	1.8
151-180	237	1.6	247	2.0	60	1.7

Table 2

Amount of DDT in scrapings taken during the first thirty days after spraying walls of houses in Venezuela

Portion of wall	1-5 sprayings		6-10 sprayings		11-15 sprayings	
	Number of samples	Gms per sq. mt.	Number of samples	Gms per sq. mt.	Number of samples	Gms per sq. mt.
Upper	919	2.1	1,052	3.5	388	3.4
Middle	914	1.8	1,054	3.0	385	2.8
Lower	915	1.8	1,056	2.8	386	2.7

Table 3

Grammes of DDT per square metre in each band of 5 cms width of the upper, central, and lower portions of the spraying swath

5 cm wide bands of swath from left to right	Upper portion	Central portion	Lower portion
1	0.98	0.61	0.09
2	1.38	0.60	0.50
3	1.80	1.33	1.08
4	2.20	2.44	2.10
5	2.90	3.23	2.48
6	3.31	3.27	3.25
7	3.72	4.93	4.37
8	3.67	5.88	5.38
9	3.58	5.42	5.82
10	3.22	6.28	6.02
11	3.32	5.75	5.68
12	3.33	5.90	4.74
13	3.58	4.29	4.71
14	2.85	3.85	3.42
15	2.30	2.96	2.65
16	1.88	1.81	2.48
17	1.47	0.91	0.93
18	0.98	0.34	0.25
19	0.57	0.23	0.03
20	0.31	0.58	0.06

Table 4

Distribution of samples of wall scrapings
collected in the same houses of Cagua, Aragua,
to show normal variation of DDT contents

Gms/m ²	First month	Second month	Third month	Fourth month	Fifth month	Sixth month
1	8	8	16	26	21	9
1,0-1.9	6	4	6	4	3	9
2,0-2.9	26	18	7	10	11	12
3,0-3.9	9	13	23	13	6	3
4,0-4,9	3	7	7	1	6	3
5	6	7	1	0	4	3
Average gms/sq. mt	2.89	3.09	2.42	1.58	2.43	2.26

Potentiometric determination of H in water through which
passed air with decomposition products

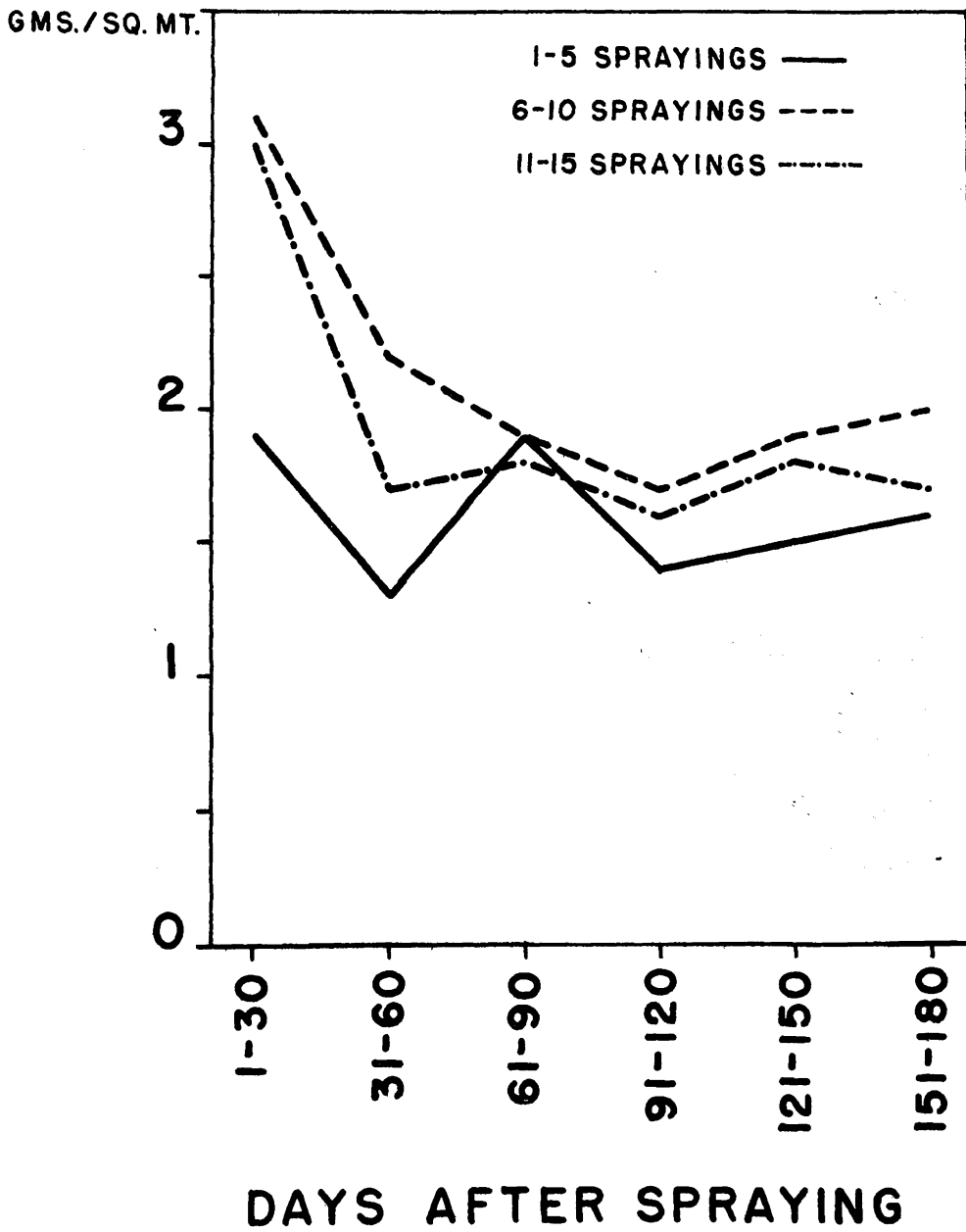
Hours	DDT technical	p.p'-DDT	Earth	DDT and earth	p.p'-DDT and earth
2	6.55	5.35	5.50	5.50	4.90
4	6.20	5.25	6.30	3.65	1.95
6	6.75	5.20	5.50	5.80	3.10
8	6.40	5.40	5.50	5.60	3.35
10	5.85	5.60	5.70	4.75	3.65
12	6.30	6.00	6.00	2.00	3.70
14	6.15	5.15	5.70	2.25	-
16	-	5.30	5.50	2.65	-
18	-	5.10	5.50	2.70	-
20	-	-	5.40	3.15	-
22	-	-	5.40	2.90	-
24	-	-	-	3.15	-

Table 6

Presence of *A. albitalarsis* in sprayed and unsprayed houses of the same locality in the neighbouring states of Barinas, Portuguesa, Cojedes and Guarico (1948 - 1952)

Months after spraying	DDT in houses	Capture Stations		Adults collected	Infection index	Density index
		Visited	Positive			
1	yes	1,390	71	470	5.1	33.8
	no	267	29	368	10.9	137.8
2	yes	1,013	62	322	6.1	31.8
	no	89	14	202	15.7	227.0
3	yes	773	43	518	5.6	67.0
	no	54	10	58	18.5	107.4
4	yes	866	45	321	5.2	37.1
	no	218	30	231	13.8	106.0
5	yes	842	40	297	4.8	35.3
	no	136	33	570	24.3	419.1
6	yes	724	58	391	8.0	54.0
	no	118	40	357	33.9	302.5
Total	yes	5,608	319	2,319	5.7	41.4
	no	882	156	1,786	17.7	202.5

AMOUNTS OF DDT FOUND ON MUD-WALLS AFTER DIFFERENT SPRAYINGS



DECOMPOSITION OF DDT WHEN MIXED WITH EARTH

