THE OCCUPATIONAL HAZARD OF DDT SPRAYING

BY

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From Lagos, British West Africa

The ideal insecticide, like the ideal antiseptic, should have as one of its main properties a marked lethal effect on the organism attacked, and a minimal toxic effect on man or animals. Thus it is no accident that DDT and penicillin have assumed so prominent a place in hygiene and therapeutics respectively, for they both are strongly toxic to certain undesirable forms of life and relatively harmless to man. However, evidence as to the lack of toxicity to man of DDT, up to date, is almost entirely confined to laboratory experiments on animals, a few human volunteers, and personnel engaged in the manufacture of DDT. An excellent opportunity presented itself to me on arrival in West Africa to investigate the toxic action of DDT in the field on a team of twenty-seven whole-time African sprayers, civilians employed by the army. The duration of the experiment was six months, from May to October, 1945, when it had to be concluded as the labourers were discharged. During these six months 28 cwt. 78 lb. of crude DDT, dissolved in 7428 gallons of kerosene were expended, and on an average each man was responsible for the distribution of over one hundredweight of the crude powder dissolved in kerosene in the proportion of 6·8 oz. to the gallon. The percentage purity of the DDT varied considerably from sample to sample, some batches being as low as 52 per cent., others up to 61 per cent. Spraying was carried out on five days of each week, on all military accommodation in Lagos; nine of the men were also employed in spraying DDT on mosquito breeding grounds. The sixth day was spent in repairing apparatus and vehicle maintenance. The apparatus used was either the Mackenzie or the Four Oak's sprayer. At first complete instructions were issued for personal protection against possible absorption, the wearing of gloves, gas capes, and eye shields, and for provision of an anti-drip can on the Mackenzie sprayer to catch the large amount of spray that ran back from the nozzle on to the operator's hands. However, it was soon apparent that no amount of ordering would convince these African civilians of the necessity for precautions, and it may be accepted that after the first few weeks no precautions at all were taken. However, there was no great risk, as the men were kept under constant supervision. The only exception was that personnel actually engaged

in mixing and dissolving the DDT had to wear elbow-length gloves. This could be insisted upon as the individuals concerned worked within visual distance of the orderly-room.

Considerable work has been done on the toxic properties to mammals of DDT (Cameron (1945); Buxton (1945)). DDT in powder form applied to the skin is harmless, but if dissolved in an organic solvent such as acetone or kerosene it can be absorbed through the skin and cause poisoning. DDT in aerosol or mist form in any strength likely to be used has been shown to be non-toxic to human beings. Ingestion of small amounts regularly will eventually cause poisoning in man, but apart from eating sprayed fruit or vegetables, or by accidental ingestion, this hazard is not likely to occur. Only three cases of poisoning in man have been reported. Wigglesworth (1945) described poisoning in a laboratory worker who carelessly handled DDT in acetone; Case (1945) reported evidence of absorption through the skin in two volunteers under certain specific experimental conditions; and Hill and Robinson (1945) reported the death of a 19 months old African child who drank one ounce of 5 per cent. DDT in kerosene. Early warning of intoxication may be the appearance of anorexia. Nervous manifestations, such as hyperexcitability, inco-ordination, muscular weakness, tremors, and convulsions predominate. Post mortem, the most obvious sign is degeneration of the liver. Cameron (1945) states that experience in animals has shown that features of value in assessing toxic absorption are a rapid decrease in weight, development of anaemia and leucocytosis, and perhaps a rise in blood calcium. Accordingly, in this work, these have been the signs looked for. There are no records of dermatitis from DDT, and sensitization is uncommon (Buxton, 1945).

Present Investigation

The spraying began in May, but this investigation did not commence until July. This meant that data were, unfortunately, not available concerning the subjects before spraying commenced. At the end of July, August, September, and October each subject was weighed and examined clinically. Blood calcium estimations, haemoglobin, white blood count, and differential were done on each

individual twice, one in August and again in October.

At the end of August, not only was the average weight of the sprayers less than 9 stone, but the average weight was going down, and the number who lost weight was seventeen as compared with eight

TABLE 1

The results of the weighings are as follows:

	July	August	September	October
J.E. ..	131	130	130	132
O.I. ..	120	120	120	122
U.E. ..	115	111	121	122
A.Y. ..	126	125	129	132
B.A. ..	118	115	111	119
P.I. ..	118	120	115	120
E.O. ..	136	138	140	142
O.O. ..	138	134	135	138
O.A. ..	118	115	112	115
O.A. ..	106	101	105	108
S.B. ..	115	116	117	120
W.O. ..	126	124	125	130
J.O. ..	150	149	152	155
D.E. ..	115	111	114	122
O.L. ..	120	120	120	121
O.O. ..	127	126	124	131
O.R. ..	160	159	164	162
J.O. ..	118	116	121	120
O.V. ..	117	113	105	105
A.A.B. ..	131	130	132	Sacked
S.A. ..	132	130	131	138
D.A. ..	111	115	129	128
M.M. ..	133	131	132	132
T.D. ..	116	112	115	115
J.O. ..	126	126	131	130
A.S. ..	134	136	135	142
B.A.B. ..	130	130	134	135

TABLE 2

	No.	Average Weight	Gains	Losses	No change
End July ..	27	125.4	—	—	—
End Aug...	25	125.0	4	17	4
End Sept...	27	125.9	17	5	3
End Oct. ...	27	127.9	19	4	3

stationary or gaining. It was then that the absence of a control group was felt. Thirty grass-cutters were chosen and weighed monthly from the end of August on. Their weights were as shown in Tables 3 and 4.

It will be seen from this that at the end of August the controls weighed slightly less than the DDT workers, and in the subsequent two months the course in the two groups was much the same, so the poor weights were unlikely to be due to DDT. Thirteen soldiers were then weighed and the average weight was 141.3 lb., 24 lb. more than the average of the

TABLE 3

	August	September	October
B.O. ..	115	119	118
S.E.X. ..	131	133	130
P.O. ..	130	134	128
R.I. ..	135	140	136
R.E. ..	112	120	116
J.O. ..	111	120	120
J.A. ..	132	139	138
A.N. ..	92	102	—
S.A. ..	130	128	130
E.O. ..	110	113	—
J.I. ..	116	120	116
U.J. ..	122	131	130
O.S. ..	120	125	120
U.T. ..	130	130	130
J.O. ..	112	115	130
E.J. ..	122	129	129
O.S. ..	121	124	126
P.A. ..	111	118	—
E.S. ..	110	113	114
I.J. ..	116	115	126
U.M. ..	112	115	117
S.O. ..	124	128	128
A.A. ..	118	111	—
A.J. ..	141	147	148
M.E. ..	126	130	138
M.O. ..	104	105	101
A.U. ..	111	114	116
D.I. ..	111	114	104
J.N. ..	132	131	128
D.U. ..	116	116	118

TABLE 4

	No.	Average Weight	Gains	Losses	No change
End Aug...	30	119.1	—	—	—
End Sept...	30	122.6	24	4	2
End Oct. ...	26	124.4	10	12	4

civilians. The combined average weight of the thirty civilians and thirteen soldiers was 126 lb.

Thus the difference in weight between the civilians

TABLE 5

	Civilians	Soldiers	Total
Above Av. Wt. ..	9	10	19
Below Av. Wt. ..	21	3	24
Total ..	30	13	43

$$\chi^2 = 6.3 \quad P > .01 < .02$$

and soldiers is significant. As there are a number of tribes involved, difference in weight might have been due to difference in tribe. All the civilian controls were Ibos, the average weight being 119.1 lb. Of nine Ibo soldiers the average weight was 143.4 lb., a similar result to civilians and soldiers generally. As the difference was not due to tribe,

TABLE 6
WHITE BLOOD COUNTS AND DIFFERENTIAL COUNTS
(First column in each case refers to August, second to October.)

	W.B.C.		In. or dec.	Poly.		Lymph.		Mono.		Eosin.		Baso.	
J.E. ..	5000	10600	+	60	58	30	33	2	4	7	5	1	0
O.I. ..	6800	9000	+	66	72	31	21	0	4	3	3	0	0
U.E. ..	8000	9800	+	58	66	28	27	4	3	10	4	0	0
A.Y. ..	8000	9600	+	45	58	52	38	1	2	2	2	0	0
B.A. ..	4000	9800	+	65	70	28	22	1	5	6	3	0	0
P.I. ..	8500	10000	+	66	70	30	27	1	3	3	0	0	0
E.O. ..	5800	6800	+	61	62	34	29	2	2	3	6	0	1
O.O. ..	5000	11200	+	70	66	24	28	2	3	3	3	1	0
O.A. ..	4000	11000	+	75	72	20	20	1	6	4	2	0	0
O.A. ..	3900	9600	+	67	66	24	29	4	2	5	2	0	1
S.B. ..	4900	6800	+	66	66	27	30	1	2	6	2	0	0
W.O. ..	8000	9200	+	61	60	34	32	1	4	4	4	0	0
J.O. ..	4800	10000	+	70	59	25	33	1	3	4	4	0	1
D.E. ..	5000	7800	+	59	63	31	27	2	5	8	5	0	0
O.L. ..	6000	9600	+	62	63	32	28	3	5	3	4	0	0
O.O. ..	8000	8800	+	67	63	25	34	2	3	5	0	1	0
O.R. ..	5500	7800	+	63	52	30	44	1	4	6	2	0	0
J.O. ..	7700	8000	+	67	78	27	12	3	6	3	3	0	1
O.V. ..	5100	7600	+	64	66	32	28	1	2	3	2	0	2
A.A.B. ..	6800	—	—	60	—	35	—	1	—	4	—	0	—
S.A. ..	9000	7000	—	69	68	26	24	1	6	4	1	0	1
D.A. ..	8600	6800	+	66	68	27	26	3	5	2	3	2	1
M.M. ..	7500	8800	+	65	72	27	19	6	6	2	3	0	0
T.D. ..	5300	7200	+	65	66	26	27	3	3	5	4	1	0
J.O. ..	9000	—	—	74	—	23	—	3	—	0	—	0	—
A.S. ..	7000	—	—	65	—	30	—	2	—	3	—	0	—
B.A.B. ..	6400	—	—	58	—	32	—	4	—	6	—	0	—

and as all the people involved lived in Lagos, it was probably due to malnutrition and, perhaps, a certain pre-enlistment selection, a supposition fully supported by economic conditions in Lagos at that time. The civilians were paid 2s. a day, and food was scarce and controlled. Political tension ran high, and in late July and early August there was a strike of all transport workers, making the food situation even more difficult. After the strike conditions improved, and this was reflected in the slight gains in weight of the civilians in September and October. The final conclusion is, therefore, that there was no significant change in weight that could be attributed to DDT.

Leucocyte Counts

The individual counts show little of significance. However, it may be noted that of twenty-three white blood counts, twenty-one showed an increase between August and October. The counts were made in the morning. Unfortunately there was not a control series, so there can be no certainty that this was due to DDT.

Haemoglobin and Blood Calcium

In August haemoglobin and blood calcium estimations were done on the DDT sprayers. For the haemoglobin the Sahli method was used. The main feature is that the October haemoglobins and blood calciums both lie within normal limits. A certain minor erratic distribution of some results is due to the varying technical abilities of the laboratory assistants.

TABLE 7

	Haemoglobin		+ or —	Blood Calcium		+ or —
	August	October		August	October	
J.E. ..	14.5	14.1	—	10.0	9.5	—
O.I. ..	11.3	14.1	+	9.5	9.1	+
U.E. ..	14.0	13.2	—	8.0	9.5	+
A.Y. ..	12.5	14.1	+	9.5	10.0	+
B.A. ..	12.6	13.8	+	9.3	9.2	—
P.I. ..	13.5	13.5	—	9.0	10.6	+
E.O. ..	14.5	13.1	—	10.0	9.5	—
O.O. ..	15.0	13.2	—	9.5	9.8	+
O.A. ..	12.0	13.1	+	8.5	9.6	+
O.A. ..	12.4	13.8	+	10.0	10.0	—
S.B. ..	14.0	13.8	—	8.5	9.6	+
W.O. ..	12.2	13.5	+	10.0	10.4	+
J.O. ..	13.2	13.5	+	9.5	10.4	+
D.E. ..	10.7	13.2	+	9.0	10.0	+
O.L. ..	13.5	13.8	+	9.8	9.0	—
O.O. ..	14.0	13.5	—	10.0	10.6	+
O.R. ..	14.4	13.2	—	9.8	10.5	+
J.O. ..	15.0	13.8	—	10.5	9.3	—
O.V. ..	14.6	13.8	—	9.5	10.0	+
A.A.B. ..	13.0	—	—	9.5	—	—
S.A. ..	12.3	13.8	+	9.2	9.8	+
D.A. ..	13.5	13.2	—	10.0	10.3	+
M.M. ..	14.0	13.8	—	10.8	9.3	—
T.D. ..	14.5	13.5	—	9.5	10.0	+
J.O. ..	13.4	—	—	10.5	—	—
A.S. ..	13.8	—	—	11.0	—	—
B.A.B. ..	16.8	—	—	10.5	—	—

Skin Rashes

Apart from the rashes to be mentioned, nothing of note was found at the monthly inspections. Some acquaintance with the literature, experience in Europe with anti-louse powder containing DDT and liquid spraying with a kerosene solution would convince anyone that no trouble was to be expected with skin irritation. However, immediately on arrival in West Africa a different story was told me by the N.C.O.s., who stated that skin trouble was prevalent, especially when DDT spraying first started. Examination of the sprayers, however, showed that whatever might have been the situation in May they were free from trouble in July, with the exception of the mixer, A.A.B. It was decided to investigate the situation by means of patch tests.

The first week in September 27 DDT workers were tested, and shortly afterwards 30 controls (grass-cutters). A piece of lint about 1 in. square was lightly damped with the test solution, 5 per cent. DDT in kerosene, and fixed to the right arm with plaster. Kerosene only as a control was placed on the left arm. The patch was applied at 4.30 p.m. and read at 8.30 a.m. the next day. The result among the non-DDT contacts was as follows:—

TABLE 8

No.	Test Arm	Control
12	—	—
2	+	+
13	+	—
1	++	—
2	+++	+

Four showed a small reaction with kerosene, all four of whom also showed a similar or larger reaction with the DDT in kerosene on the other arm. Fourteen showed a reaction to the DDT in kerosene, but not to the kerosene alone. The reaction was vesicular, the smallest rash consisting of a few scattered vesicles the size of a pinhead, and the largest a blister the size of the patch, with oedema. These 30 controls were next similarly tested with a 5 per cent. solution of DDT in dimethylphthallate (DMP). None showed any evidence of a rash whatsoever. It is well established in Europe by the delousing of millions that DDT powder is non-irritant, as shown here DDT in DMP is non-irritant, kerosene (for this experimental contact period) was slightly irritant, but 5 per cent. DDT in kerosene considerably irritant. This is true of Europeans (of whom 6 were tested) as well as Africans. The conclusion seemed to be that DDT, whilst innocuous on its own, considerably enhances the vesicant action of kerosene. This applies to the controls, who had not been in contact with DDT. With the 27 DDT contacts the results were quite different, in early September only 3 showed a moderate reaction to the DDT in kerosene, and none to kerosene alone, one of these three was the

mixer, but by the end of October, out of 26 remaining none showed any reaction to DDT in kerosene or the control. This difference is, of course, highly

TABLE 9

	DDT Workers	Controls	Total
Positive to either test or control ..	0	18	18
Negative to both test and control	26	12	38
Total	26	30	56

$$\chi^2 = 20.3$$

significant. A.A.B., the mixer, was noted to have a rash, papulosquamous in type, on arms, front of abdomen and thighs. He was also positive to the patch test. He was taken off mixing and the rash improved. However, the rash could not be followed up for a long period as, owing to drunkenness, he had to be discharged. A soldier was put in his place, and also developed a rash, but he in his turn could not be investigated as he was sent to prison. The third soldier who took on mixing likewise got a rash, which, however, soon cleared up.

It seems, therefore, that sensitivity to DDT in kerosene disappears with continual contact, and that the mixers are far more likely to get a rash than the sprayers.

This was well illustrated early in December when soldiers took over spraying from the discharged civilians. Complaints of rashes among the sprayers were soon made, 5 out of a total of 12 had some trouble, as compared with none of the recently-discharged civilians. Reference in literature to irritation seems confined to the description by Nelson and his colleagues (1945) in experimental animals of a mild dermatitis with hyperkeratosis and very little cellular infiltration. In more severe cases there was a slight focal epidermal necrosis. Macdonald, in a discussion after presentation of a paper by Buxton (1945) records dermatitis in a sprayer, and states there was no evidence to differentiate it from a kerosene rash; Cameron (1945) describes severe inflammation of the skin in rabbits who had been subjected to cutaneous applications of DDT in kerosene. He suggested that the kerosene alone might be responsible for this.

Discussion

That the vehicle in which DDT is incorporated may cause more trouble than the DDT is apparent with kerosene. Anti-louse powder is made up with china-clay, and if powdering is performed indoors, either by ignorance of the correct technique or because of weather that makes it impossible to carry on out of doors, the room becomes full of a cloud of dust. Sore eyes, nose and throat are soon complained of, and it becomes impossible to

continue working in the atmosphere without wearing a mask, all the symptoms undoubtedly due to the diluent. Manufacturers should keep in mind the fact that the vehicle may cause more complaints than the active substance, which in practice has never caused any trouble.

It would not be out of place here to suggest that kerosene be used no longer than is absolutely necessary as a solvent for DDT. It has been used hitherto because it is in good supply and cheap. As kerosene has been available locally, DDT could be shipped in powder form and thereby save considerable shipping space. The disadvantages are that kerosene has an objectionable smell, may stain walls, ruin rubber and fabrics, and be irritant to the skin; and it is immiscible with water. DDT should be provided in an emulsion form when a liquid spray is required as soon as is commercially practicable.

Summary

1. Blood examinations, regular weighings, and skin inspections have been carried out on 27 African whole-time DDT sprayers. Although these men were probably undernourished and took no precautions against skin absorption, no signs or symptoms of DDT poisoning were found. Slight increases in the leucocyte count were noted.

2. When DDT was used in kerosene, rashes were common when sprayers first started on the work. After some months, however, they became desensitized. By means of patch tests it was shown that the irritation is primarily due to the kerosene, and made considerably worse by the DDT dissolved in it. DDT alone is innocuous. A plea is made for the discontinuance of kerosene as a solvent for DDT.

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