

THE IMPACT OF FENITROTHION (OMS 431) SPRAYING ON MALARIA PREVALENCE IN AN AREA OF INDIA WITH *ANOPHELES CULICIFACIES* RESISTANT TO DDT, LINDANE AND MALATHION

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ABSTRACT. There was a resurgence of malaria in India following resistance of the vector to DDT, lindane and malathion and an alternative insecticide was sought to meet emergency cases. A large field trial was carried out to determine the impact of a single application of fenitrothion at 2 g/m² in a triple resistant area of Gujarat State, India. The results showed that the residual effect lasted for over three months and that fumigant action lasted for 71 days after spraying, bringing about a decrease in malaria prevalence.

INTRODUCTION

The National Malaria Eradication Programme of India, initiated in 1953, was switched over to that of Malaria Eradication in 1958. The insecticide for indoor spraying was DDT to which the vector *An. culicifacies* Giles was highly susceptible. Up to 1960, the endemic and hyperendemic areas of India received two applications of spray at a dosage of 1 g/m², usually spaced 10 weeks apart. The period of insecticide application was generally May to October. Later in certain selected hyperendemic areas where there was evidence of spring transmission, an additional application at a rate of 1 g/m² was made during March. Increased tolerance to DDT and later resistance in *An. culicifacies* was detected in 1959 and 1960, respectively (Luen and Shalaby 1962).

A field trial on the comparative efficacy of DDT and lindane at 1 g/m² and 0.2 g/m², respectively, was conducted in 1960 in a DDT resistant area of Baria Taluka, Godhra District, Gujarat State. Based on results obtained in this trial, selected areas of Gujarat and Maharashtra states were sprayed with lindane applied at 0.2 g/m². Three applications were spaced at six weeks' intervals.

Since the vector *An. culicifacies* became highly resistant to both DDT and lindane (Sharma and Samnotra 1962), and the incidence of malaria was increasing at an alarming degree, selected areas in Gujarat and Maharashtra states were sprayed with malathion in 1969. Three applications (annually) were usually made at 6 weeks' intervals at a rate of 2 g/m². From 1977 onwards, *An. culicifacies* has also shown lowered susceptibility to malathion (Rajagopal 1977), so that there have been areas in the two states

where the vector has become resistant to DDT, lindane and malathion. Malathion spraying in these areas did not lower the incidence of malaria, although in some areas it may have checked the rise in incidence.

From an operational point of view, a need arose to have an effective insecticide which could be used in such areas to control malaria. Fenitrothion (Sumithion/Folithion) OMS 43, (0,0-dimethyl 0-(4 nitro-metatolyl phosphorothioate) was evaluated by the WHO Research Unit near Kisumu, Kenya (Fontaine et al. 1976), at a dosage of 2g/m² at 3 months' intervals against *An. gambiae* Giles, *An. arabiensis* Patton and *An. funestus* Giles. Results showed that the densities were reduced to negligible levels for 10 months after the last spraying. Further, marked and rapid decreases in malaria incidence were recorded.

In India, Bhatia et al. (1969), using Sumithion (fenitrothion) 40% water dispersible powder applied at rates of 0.5 g/m² and 1 g/m² in an *An. culicifacies* area in Maharashtra State where this vector was already resistant to DDT and lindane, found that fenitrothion was effective for 6 to 10 weeks.

Under the auspices of the National Institute of Communicable Diseases, Bhatnagar et al. (1974) applied fenitrothion against DDT resistant *An. culicifacies* in Alwar District, Rajasthan State. They showed that 0.5 g/m² was effective for 5 weeks and at 1 g/m² it was effective for 8 weeks. The effect of the prevalence of malaria was not studied. Among the spraymen only one showed a slight (87.5%) lowering of cholinesterase level.

The impact of fenitrothion spraying on malaria was studied by Wattal et al. (1978) in Godhra District, Gujarat State, where the vector *An. culicifacies* was also resistant to DDT and lindane. Fenitrothion was effective at 1 g/m² for 8 to 9 weeks. A decline in incidence of malaria cases was recorded with a significant reduction (49%) in *P. falciparum* cases. No cases of

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cholinesterase inhibition were observed among either spraymen or inhabitants.

In the Lahore area of Pakistan where *An. culicifacies* was resistant to DDT and lindane, Sumithion sprayed at a rate of 1 g/m² (two applications) was effective for 68 days (nearly 10 weeks). The malaria parasite rate, particularly of *P. falciparum* recorded a sharp decline.

This field trial was undertaken in an area in Surat District where *An. culicifacies* was resistant to DDT, lindane and malathion. It was decided that a single application of 2 g/m² would be sprayed at an epidemiologically appropriate time. It was postulated, on the basis of Kisumu (Kenya) trials, that the effect at 2 g/m² might last for 12 weeks and if this was followed by a period of heavy rains, the breeding sources of the vector would remain flushed out so the transmission period would be reduced. Moreover, the proposed trial was to be not on village scale but would cover a larger population.

MATERIALS AND METHODS

The trial was carried out in the three sections of Champawadi Primary Health Centre, Surat District, Gujarat State. The climate of the area is hot/humid from March to June. This is followed by rainy months from July to September. October generally remains hot/dry and November to February remain cold and dry. The average annual rainfall is about 1895 mm. The average maximum and minimum temperatures are 45°C and 11°C, respectively.

The area is well irrigated by canals and tributaries. Water in the irrigation channels is generally released once every 15 days. The most important crop of the area is millet. Other important crops are cotton, sugarcane, etc.

Houses are grouped into small hamlets and a group of hamlets forms a village. The number of such villages in the trial area were 17. Details of population, etc. are given in Table 1. The distance between hamlets is from less than a

kilometer to 1.5 km. Villages are 3 to 4 km apart. The houses have mud plastered walls and thatched roofing. A few pukka houses were also present. Walls extending up to roofs have many cracks and spaces. Open eaves of the houses provide ready ingress and egress for mosquitoes. Domestic animals are generally kept at night in enclosed shelters within the houses. The inhabitants are cultivators-cum-laborers and are of a tribal community. As such there is constant migration of individuals or families.

As regards the insecticide spraying history of the area, up to 1978, 25 applications of DDT and 24 applications of lindane had been sprayed. Since 1971 the area was sprayed with malathion and had received 16 applications.

The susceptibility of *An. culicifacies* to various insecticides was determined by WHO techniques prior to the initiation of the field trial (WHO 1975). Mosquito survivals were: DDT 84.7%, dieldrin 86.9% and malathion 69.4%. *Anopheles culicifacies* was found to be highly susceptible to fenitrothion.

SPRAY OPERATIONS. Timing of the spraying application was based on the positive incidence of malaria recorded during the previous year. It was postulated that a single spraying of 2 g/m² in April would provide protection up to July and then the rainy season would commence, which would continue to flush out the larval breeding sources. Thus, the effect of the single application would be drawn out and would take care of an entire year's transmission period.

Indoor spraying with fenitrothion was carried out from April 23-29, 1979. The formulation was 40% water dispersible powder, the suspension being prepared on site at the time of spraying. The dosage was 2 g/m² and application was made with stirrup pumps. The control area received malathion at the usual dosage of 2 g/m² currently in use in the area. Attempts were made to cover all houses including cattle sheds. The acceptance response from the public was very good as the material applied was odorless

Table 1. Number of villages, population, etc. of treated and comparison areas in Surat District, Gujarat State India.¹

Section	Nature of area	Number of villages	Population	Insecticide treatment (2 gm/m ²)	Dates of spraying
I	Treated	6	5039	Fenitrothion 40% WDP	April 23-29, 1979
II	Treated	4	6316	Fenitrothion 40% WDP	April 23-29, 1979
III	Comparison	7	5146	Malathion 25% WDP	May 16-20, 1979

¹ The area has been sprayed with malathion since 1971 and 16 applications had been made earlier, 25 application of DDT and 24 application of lindane had been made from 1953 onwards.

and other insect pests were simultaneously killed.

SAFETY PRECAUTIONS. All necessary safety and protective measures were adopted. These included intensive supervision to ensure that the standard personal protective procedures were adopted by all concerned. Use of clean uniforms, changing the uniforms every day, use of gloves, plastic eyeglasses, muslin cloth masks, PVC brimmed hats, shoes and copious use of soap for washing was enforced. Special stirrers were used for mixing the suspensions. The equipment was kept in a good state of repair to avoid contamination by leakage. Supervisory staff trained in detection of early symptoms of insecticide intoxication were provided with Atropine tablets, although no such emergency arose during the operations.

The operators were subjected to initial screening and those found with low cholinesterase level were dropped from the spray parties. Visual observation of the general health of the workers by the supervisory staff was the main criteria relied upon. Cholinesterase levels of the spraymen and some of the villagers were taken before and after the operations.

ENTOMOLOGICAL EVALUATION. Observations on mosquito populations in the test and control areas were made before and after spraying of the insecticide, at fortnightly intervals. Villages for mosquito collections were fixed. In each selected village, 10 fixed and 10 random houses were searched—15 min spent in each station. Collections were made during morning hours.

carried out before and after the spraying to find the parasitic reservoir in the community (particularly among asymptomatic persons).

RESULTS

TOXICOLOGICAL. Altogether, 120 village inhabitants and 38 spraymen were checked for cholinesterase levels before and after the spraying operations. Four out of 120 inhabitants had cholinesterase levels of 87.5%, before spraying. One week after spraying, 12/91 inhabitants had a cholinesterase level at 87.5% and 2 had 75%. All of the 38 spraymen had a cholinesterase level of 100%, before spraying. After spraying one had 87.5%, one had 75%, one had 62.5% and three were below 50%. During spraying there were no complaints or other symptoms among the inhabitants or spraymen.

ENTOMOLOGICAL. Entomological effectiveness of the insecticide was checked on the prespray and postspray vector surveys. The vector counts, as well as the number of all *Anopheles*, were found to be nil after spraying. The average number of mosquitoes collected increased and reached a level of 25.1 mosquitoes per man hour in 12 weeks. In the control area, however, it gradually increased to 89.6 per man hour (Table 2).

Bioassays carried out on the mud surfaces sprayed with the insecticide showed over 50% mortalities even after 3 months. (Table 3). Studies on the airborne effect of the insecticide

Table 2. Mosquitoes collected per man hour (average of all *Anopheles* mosquitoes and *An. culicifacies* collected).

Section	Nature of area and dates of spraying	Mosquitoes (per man hour average) ¹ collected			
		Before spraying	After spraying		
			May	July	August
I	Treated with fenitrothion	37.3	0.0	19.4	77.0
	April 23–29, 1979	(6.6)	(0.0)	(8.8)	(52.2)
II	Treated with fenitrothion	44.0	0.0	25.1	69.4
	April 23–29, 1979	(14.6)	(0.0)	(13.6)	(17.4)
III	Comparison, treated with malathion	192.6	47.6	89.6	225.4
	May 16–20, 1979	(69.3)	(4.0)	(23.6)	(31.4)

¹ All *Anopheles* and *An. culicifacies* given in parentheses. No work was conducted during June.

Further contact bioassay tests in accordance with standard methods were carried out at suitable intervals. Airborne fumigant effect studies were carried out according to the WHO approved techniques.

EPIDEMIOLOGICAL EVALUATION. The observations were based on the monthly prevalence of malaria as recorded during the surveillance procedures. The procedures were comparable for 1978 and 1979. Mass blood surveys were

were made and 100% mortality was observed up to 71 days after application. Thus it was established that the insecticide not only had a long residual effect (3 months), but also had a residual airborne effect for nearly 71 days (Table 4).

EPIDEMIOLOGICAL. Mass blood surveys were carried out before and after spray operations. In the treated area, 3.1% of the 4991 blood smears were positive for malarial parasites be-

Table 3. Results of bioassay tests (wall cage) with *Anopheles culicifacies* in the areas sprayed with fenitrothion.¹

Date of test	Number of days after spraying	Number exposed test	Control	Number dead in test after			Percent mortality	
				30 minutes	24 hours	Control	Test	Control
June 9, 1979	47	69	40	0	69	0	100.0	0.0
July 9, 1979	77	80	40	4	76	0	100.0	0.0
July 25, 1979	93	80	40	0	65	1	81.2	2.5
Aug. 5, 1979	104	80	40	0	46	1	57.5	2.5
Aug. 27, 1979	126	80	40	0	20	0	25.0	0.0
Sept. 4, 1979	132	80	40	0	13	0	16.2	0.0

¹ Bioassay tests used wild caught, fed female mosquitoes. The areas were sprayed with fenitrothion April 23-29, 1979.

fore spraying and 1.5% after spraying. In the control area however, it was 2.7% before spraying and 6.9% after spraying (Table 5).

Table 4. Results of tests to determine fumigant action by exposing *An. culicifacies* mosquitoes in cages away from walls sprayed with fenitrothion as per WHO procedures.¹

Section	Days after spraying when exposed	Hours of exposure for 100% mortality	Temperature (°C)
I	9	4	39.0
	11	4	39.0
	14	4	39.0
	18	8	37.5
	22	8	38.0
II	71	12	29.0
	9	4	39.0
	11	4	41.0
	14	4	41.0
	18	5	37.5
	22	6	35.0
	71	6	29.0

¹ The areas were sprayed with fenitrothion April 23-29, 1979. Forty mosquitoes were used for each test.

This showed that in the control area low grade transmission of malaria had taken place.

Malaria prevalence in the treated area before spraying was 31.4% and 30.2%, respectively, for 1978 and 1979 (March). However in the postspray period it declined tremendously (Table 6). Thus, it will be seen that sustained decline in the prevalence of malaria resulted from the spray of this insecticide. In the control area which received just malathion, the decrease was only in June following the spraying. The detailed figures for 1979 are given in Table 7.

CONCLUSIONS

During the present field trial fenitrothion was applied at a rate of 2 g/m² against triple resistant (DDT, lindane, malathion) *An. culicifacies*. Satisfactory control was obtained for over 3 months. In addition, the insecticide was found to have a fumigant effect for 71 days. Based on data from mass blood surveys, the insecticide was effective in bringing about a sharp decline in the parasitic reservoir of infection. Surveillance showed a decrease in the morbidity. Toxicity studies showed that there

Table 5. Results of mass blood surveys from the treated (with fenitrothion) and comparison areas before and after spraying.

Period of survey	Age group (years)	Treated area			Comparison area		
		Number examined	Number positive for malaria	Percent positive	Number examined	Number positive for malaria	Percent positive
Pre-spray (April 1979)	0 to 1	94	1	1.1	39	1	2.6
	2 to 4	646	12	1.9	252	6	2.4
	5 to 14	1595	63	3.9	731	26	3.4
	Above 14	2656	52	2.0	1125	25	2.2
Total		4991	138	3.1	2177	58	2.7
Post-spray (June 1979)	0 to 1	7	0	0.0	5	0	0.0
	2 to 4	60	2	3.3	32	1	3.1
	5 to 14	201	3	1.5	67	8	11.9
	Above 14	202	1	0.5	83	4	4.8
Total		470	6	1.5	107	13	6.9

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