

ARTICLES

ULTRA LOW VOLUME AERIAL SPRAYING OF IODOFENPHOS AGAINST MOSQUITOES OVER RICE FIELDS AND VILLAGES IN THE ARAB REPUBLIC OF EGYPT IN 1971

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INTRODUCTION. In Egypt, the primary vector of malaria is *Anopheles pharoensis* Theobald. The use of the classical methods of control of *An. pharoensis* larvae in their breeding places, especially rice fields, using knapsack sprayers or any other ground equipment, became unsatisfactory. A marked increase in *An. pharoensis* density was observed in areas of rice cultivation. Rice is grown today not only in the governorates of the Nile Delta but also in Upper Egypt. Rice cultivation in Egypt in 1971 exceeded 1.25 million feddans. This extension in rice cultivation has resulted in a marked increase in malaria cases, especially in the years 1970 and 1971.

An agreement was made between the Dokki Institute of Medical Entomology, Cairo, and CIBA-GEIGY Limited, to use the new compound "iodofenphos" which is commercially known as @NUVANOL N, in a 20 percent ULV formulation (NUVANOL N 20 U), aerial spraying against *An. pharoensis* larvae breeding in rice fields in some villages near Cairo. Iodofenphos has a very low mammalian toxicity (average acute oral toxic dose for rats = 2,100 mg/kg) and has been found to have a remarkably persistent insecticidal and acaricidal effect. CIBA-GEIGY Limited has tried iodofenphos against mosquito adults and larvae and against house flies in various countries with good results.

MATERIALS AND METHODS. It was decided to carry out a trial with NUVANOL N 20 U by ultra low volume aerial appli-

cation over rice fields and villages in Marg area, Qalyubiya governorate. The reasons why the Marg area was chosen are:

1. There was an alarming increase in malaria cases in El-Marg especially in the years 1970 and 1971, where vivax malaria among outpatients was 40.7 percent and 43.3 percent respectively.

2. The area is nearly isolated and rice cultivation is rather restricted which assists in accurate evaluation without the interference of introduction of mosquitoes from untreated adjacent areas.

3. The area is close to Cairo, which facilitated supervision and evaluation procedures.

SELECTION OF VILLAGES AND TREATMENTS. Three villages in Marg area were selected:

First: Salama village; rice cultivation approx. 50 ha (125 feddans⁵). Sprayed with NUVANOL N 20 U at the rate of 3 lt/ha (1200 cc/feddan).

Second: Osman Moharram village; rice cultivation approx. 120 ha (300 feddans). Sprayed with NUVANOL N 20 U at the rate of 1.5 lt/ha (600 cc/feddan).

Third: Gezira village; rice cultivation 40 ha (100 feddans) selected as control, with no spraying.

The biological effectiveness of iodofenphos against Egyptian populations of *Anopheles pharoensis* adults and larvae, *Culex pipiens* adults and larvae and against house flies, was tested (Table 1), using the WHO-provided test kits and procedures (Wld. Hlth. Org., techn. Rep. Ser. 1970, Nr. 443). Impregnated papers and ethanol solutions from pure iodofen-

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⁵ One feddan = 4 200 m².

TABLE I.—Results of iodofenphos susceptibility tests on *An. pharoensis*, *Culex pipiens* and *Musca domestica* (Research Institute of Medical Entomology, Dokki, Cairo, Egypt).

Insect species	stage	Number of insects exposed	Exposure period hours	LC ₅₀ graph.	LC ₉₅ graph.	Method of Test
<i>Anopheles pharoensis</i>	adults	50	1*	0.0011%	0.0060%	Wld Hlth Org. techn. Rep. Ser. 1970, Nr. 443, Annex 1B
<i>Culex pipiens</i>	adults	60	1*	0.002%	0.018%	
<i>Anopheles pharoensis</i>	larvae stage III	100	24	0.0024 ppm	0.0017 ppm	Wld Hlth Org. techn. Rep. Ser. 1970, Nr. 443, Annex 2B
<i>Culex pipiens</i>	larvae stage III	87-100	24	0.00032 ppm	0.0016 ppm	
<i>Musca domestica</i>	adults	60	24	0.064%	0.23%	Topical application with 0.5, u on thorax.

* 24 hours observation period.

phos were locally prepared using the Busvine techniques (Busvine, 1957).

APPLICATION DATA. NUVANOL N 20 U was applied as an ultra low volume aerial spray on 24th August 1971, mid-afternoon, using a Pilatus Porter air-craft. The temperature during spraying operation was 38° C, and the flying height was less than 5 meters over open rice fields and 10-15 meters near trees and villages. The distance between aircraft tracks was 30 meters.

METHODS OF EVALUATION. Due to the importance of this trial, where a new technique in the control of mosquitoes and flies in Egypt was used, the following methods of evaluation and parameters were applied:

(A) Natural infestation with mosquito larvae and adults.

1. Average number of *An. pharoensis* larvae per dip in rice fields: 20 fixed capture stations were chosen to represent the area under investigation in each village. In each capture station (each of which is one ft²) 20 dips were examined for the presence of different stages of *An. pharoensis* larvae. The net dipper was 25 cm in diameter (Zahar *et al.*, 1959).

2. Outlet window trap catches: In each village, three bedrooms were chosen and an outlet window trap, 30 cm³ (Zahar *et al.*, 1960) was installed, all the openings were closed, a curtain was placed on the

door and kept half open during night. The door was closed just before sunrise to allow mosquitoes to come out through the window trap and be collected in the early morning.

3. Total coverage floor sheet catches: The endophilic portion of mosquitoes remaining inside the same bedroom was brought down with an ordinary flit gun using 0.15 percent pyrethrum in kerosene. The floor was covered with a white sheet (there was virtually no furniture in the chosen bedrooms) and the door was closed for 15 minutes following spraying. The door was then opened and the knocked-down mosquitoes were identified and counted.

4. Night observations. Man-mosquito relationship was determined by night catches on human baits indoors and outdoors. Collections were made for half an hour every hour from sunset to sunrise (ten periods per night). Captured female *An. pharoensis* were identified and counted, and the man biting rate was determined. Sella 1, 2 and 3 female mosquitoes were dissected and ovaries were examined to determine the parous and nulliparous ratios. (Detinova, 1952b; Polovodova, 1947).

(B) Artificial exposure of mosquito larvae and adult flies.

Third stage larvae of *Culex pipiens* were exposed in 200 ml cups, filled with

water to approx. 50 ml, at positions laid out at right angles to flying direction and parallel with it. Control cups were exposed in an untreated control village. Each cup contained 30 larvae. The mortalities were determined before and after application. 30 minutes after application all cups were brought into a protected room.

Musca domestica adults were exposed in cages at the same positions as *Culex pipiens* larvae and also at typical positions in the villages. Each cage contained 30 flies. (The fly cages consist of 4-sided folding wire frames 40 cm on a side, covered with zippered gauze screens of TERYLENE®. The gauze screen was 2 mm mesh.

(C) Evaluation of the housefly population was made by the grill method.⁶ Grills were placed inside and outside houses. Every grill was left for 40 seconds after which the average number of houseflies that came to rest on it was counted. The technique was repeated for three successive times per day at each collection point. Only averages were recorded.

The base-line information was collected, using the previous indices, in the three selected villages, 12 days, 9 days, 6 days and 1 day before spraying, and compared with data obtained 2 days, 5 days, 10 days and 14 days after spraying.

RESULTS AND DISCUSSION

(A) Natural infestation with mosquito larvae and adults.

Table 2 shows the following results:

Salama village (sprayed with NUVANOL N 20 U ULV, 3 lt/ha i.e. 1200 cc/feddan).

1. The average number of *An. pharoensis* larvae/ft² in rice fields was 13 before spraying and became nil after spraying and continued at this level for at least 5 days after which first stage larvae ap-

peared and reached the pre-spraying level only after 2 weeks after the spraying operation.

2. The average number of *An. pharoensis* females per outlet window trap, in addition to the endophilic portion caught by spraying in the same room, was 15 females pre-spraying and became nil after spraying and continued on this level for at least 5 days after which very few adult females appeared during a fortnight after spraying.

3. The average number of *An. pharoensis* females per hour that came to bite one man during night observations outdoors was 63, 13 days pre-spraying, and was reduced to only 11 females 8 days after spraying, i.e. reduction was 82 percent. The corresponding number indoors was 9.2, 12 days pre-spraying and 0.4, 8 and 13 days after spraying. The indoors reduction was, therefore, 95 percent.

4. The prespraying nulliparous ratio was 58 percent indoors and 54 percent outdoors. A week after spraying it was reduced to 33 percent and 26 percent respectively.

Osman Moharram village (sprayed with NUVANOL N 20 U ULV, 1.5 lt/ha, i.e. 600 cc./feddan):

1. The average number of *An. pharoensis* larvae/ft² in rice fields was 13 before spraying and became nil during 5 days after spraying. It increased to be only two larvae/ft² 10 days after spraying and 1 larvae/ft² 14 days after spraying.

2. The average number of *An. pharoensis* females per outlet window trap, in addition to the endophilic portion brought down by spraying in the same room, was 15 females before spraying and only two females 5 days after spraying. It increased to four females by 2 weeks after spraying.

3. The night biting rate was reduced to 12 mosquitoes per man hour outdoors and 1 mosquito per man hour indoors, a fortnight after spraying.

4. The nulliparous ratio was reduced to only 22 percent indoors five days after spraying and did not increase to its normal level until after a fortnight from the spraying date.

⁶ The Scudder Grill (or grid) is a wooden frame 80 x 80 cms. intersected by parallel horizontal wooden bars about 2.5 cms. apart. Two dark painted stripes divide it into 4 quadrants.

TABLE 2.—Evaluation of ULV aerial spraying with NUVANOL N 20 U, against larvae and adults of *Anopheles pharoensis* in rice fields, in some villages of El-Marg, Qalubia Governorate, Arab Republic of Egypt. August–September 1971.

(A) Outlet Window Trap Catches, Flitting and Larval Survey						
Days before (B) or after (A) spraying	Average no. of <i>An. pharoensis</i>		(I) + (II)	Average no. of <i>An. pharoensis</i> larvae/ft ²		
	females/window trap (I)	females/room flitting (II)				
I SALAMA Village (3 lt/ha)						
12 (B)	11.3	0.3	11.6	13.1		
9 (B)	13.3	1.7	15.0	11.7		
6 (B)	15.0	2.7	17.7	10.7		
1 (B)	13.7	3.3	17.0	15.5		
Aerial Spraying with NUVANOL N 20 U ULV (3 lt/ha) on 24.8.1971 16.17–16.45						
2 (A)	00	00	00	00		
5 (A)	00	00	00	00		
10 (A)	1.0	00	1.0	7.8		
14 (A)	1.3	0.3	1.6	13.0		
II OSMAN MOHARRAM Village (1.5 lt/ha)						
12 (B)	15.3	0.3	15.6	9.1		
9 (B)	12.0	5.7	17.7	10.1		
6 (B)	12.3	1.0	13.3	11.7		
1 (B)	13.7	1.7	15.4	23.2		
Aerial Spraying with NUVANOL N 20 U ULV (1.5 lt/ha) 15.32–16.00						
2 (A)	1.3	00	1.3	00		
5 (A)	0.3	1.3	1.6	00		
10 (A)	2.0	1.3	3.3	2.0		
14 (A)	3.0	1.0	4.0	1.0		
III GEZIRA Village (control)						
12 (B)	65.3	4.7	70.0	19.2		
9 (B)	29.0	1.0	30.0	16.0		
6 (B)	51.0	4.0	55.0	13.8		
1 (B)	21.0	6.0	27.0	23.4		
2 (A)	9.0	5.0	14.0	16.7		
5 (A)	6.3	2.3	8.6	11.4		
10 (A)	18.0	1.3	19.3	18.8		
14 (A)	10.6	1.3	11.9	12.3		
(B) Night Catches						
Days before (B) or after (A) spraying	Average no. of <i>An. pharoensis</i> bites/man/hour		Nulliparous/Parous			
			IN		OUT	
			No.	N %	No.	N %
I SALAMA Village (3 lt/ha)						
11–12 (B)*	9.2	62.9	41/30	57.8	180/153	54
7–8 (A)	0.4	10.7	1/2	33.3	20/56	26.3
12–13 (A)	0.4	6.7	2/2	50.0	17/36	35.0
II OSMAN MOHARRAM Village (1.5 lt/ha)						
7–8 (A)*	2.2	14.5	5/18	21.7	38/94	28.8
14–15 (A)	1.1	12.5	5/5	50.0	49/57	42.2

* This base-line gives information for both Salama and Osman Moharram areas.

(B) Night Catches

Days before (B) or after (A) spraying	Average no. of <i>An. pharoensis</i> bites/man/hour IN OUT		Nulliparous/Parous			
			IN		OUT	
			No.	N%	No.	N%
III GEZIRA Village (control)						
11-12 (B)	13.11	75.11	47/71	22.0	272/394	40.3
7-8 (A)	8.5	41.0	16/66	23.1	160/240	40.3
14-15 (A)	2.5	14.2	5/20	20.0	58/84	40.7

(B) Artificial layout of mosquito larvae and adult flies.

Mortality of stage III *Culex pipiens* larvae exposed at the sprayed targets was 100 percent within 1 to 3 hours after the application. Corresponding mortalities in the control village averaged approximately 0.3 percent.

Mortality of *Musca domestica* L. adults exposed at the sprayed targets was at most positions 100 percent within half an hour to 3 hours.

(C) Evaluation of the housefly population.

Table 3 presents the results of evaluation of ULV aerial spraying of NUV-

ANOL N 20 U against house flies in the selected villages. It is quite clear that the spraying operation reduced the house fly population inside and outside the sprayed villages for at least 10 days. This is considered very significant since the main objective of the spraying operation was the control of mosquitoes in rice fields and since the breeding places of house flies were left untouched.

(D) Biological effectiveness of iodofenphos: Table 1 presents the results of iodofenphos susceptibility tests on *Anopheles pharoensis*, *Culex pipiens* and *Musca domestica* in Egypt. The compound was found to be highly effective on these in-

TABLE 3.—Evaluation of ULV aerial spraying of NUVANOL N 20 U against house flies in villages.

Date of observations (Days before=B or after=A spraying)	SALAMA		OSMAN		GEZIRA	
	3 lt NUVANOL N 20 U per hectare application time (24.8.71) 16.17-16.45		1.5 lt NUVANOL N 20 U per hectare application time (24.8.71) 15.32-16.00		Control	
	Average no. of house flies per grills per day					
	In	Out	In	Out	In	Out
12.8 (12 B)	59	166	28	74	23	103
15.8 (9 B)	58	183	51	139	14	125
16.8 (8 B)	62	146	41	112	39	65
17.8 (6 B)	65	156	39	102	31	96
19.8 (5 B)	68	164	36	95	91	77
22.8 (2 B)	58	163	77	119	57	178
25.8 (1 A)	23	60	21	53	54	105
26.8 (2 A)	7	9	10	20	38	108
28.8 (4 A)	17	12	22	18	84	186
29.8 (5 A)	12	14	13	24	34	191
4.9 (10 A)	80	44	29	53	80	140

sects with LC_{50} 's of 0.0011 percent, 0.002 percent, 0.0024 ppm, 0.00032 ppm and .064 percent for adults of *An. pharoensis* and *Culex pipiens*, larvae of the same two species, and for adults of *Musca domestica*, respectively.

CONCLUSION. It is obvious that ULV aerial spraying with NUVANOL N 20 U against *An. pharoensis* in rice fields either at the rate of 600 cc/feddan or 1200 cc/feddan was very successful and resulted in the elimination of larval and adult stages of *An. pharoensis* from sprayed areas for approximately 10 days. The nulliparous ratio was reduced, indicating the decrease in new hatching from pupae during this period.

The spraying had a marked effect on the adult population of *An. pharoensis*. The adult females nearly disappeared for 5 days after spraying and reappeared only in very low numbers during 15 days after.

A decrease in adult population levels in the control area was also noticed, this might be attributed to a drift to the insecticide from the aeroplane while it was turning at the boundaries of target Osman Moharram.

A positive effect was also observed on the house fly population for 10 days, although house fly breeding places had not had any control measures directed specifically at them.

No marked difference in effectiveness against mosquitoes was observed between the village sprayed with 600 cc/feddan and that sprayed with 1200 cc/feddan. Therefore, for economy, it appears that the lower dosage can be applied.

SUMMARY. In August 1971, a trial with NUVANOL N 20 U (20 percent ULV formulation of iodofenphos) by ultra low volume aerial spraying against *Anopheles* mosquitoes breeding in rice fields of El-Marg area near Cairo, was carried out. A Pilatus Porter aircraft was used at a flying height of less than 5 meters over open rice fields and 10-15 meters near trees and villages. The swath width was 30 meters. Results showed that ULV

aerial spraying of NUVANOL N 20 U on rice fields in the selected villages using either 3 lt/ha or 1.5 lt/ha was very promising. All aquatic stages of mosquitoes and imagos nearly disappeared for a period of about 10 days, besides a marked reduction in the nulliparous ratio, indicating the absence of new hatching during this period. A good reduction in houseflies also occurred. The density was markedly reduced for at least 10 days while breeding places of house flies were left untouched. When the third stage larvae of *Culex pipiens* were artificially exposed to spraying, the mortalities, in both sprayed targets, were 97-100 percent during 1-3 hours after the application, while the corresponding control mortalities were at an average of 0.3 percent.

ACKNOWLEDGMENTS. The authors are grateful to Miss Moufida Nassif, Dr. M. Abdel Baki, Eng., I. Amin and the team of entomological technicians of the Research Institute of Medical Entomology, Dokki, Cairo. Thanks are also due to Messrs. D. Van Hees, N. Kinvig and G. Pohl of CIBA-Pilatus Aerial Spraying Company Limited for their cooperation.

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