GROUND APPLICATION OF MALATHION THERMAL FOGS AND COLD MISTS FOR THE CONTROL OF SYLVATIC VECTORS OF YELLOW FEVER IN RURAL COMMUNITIES NEAR ENUGU, NIGERIA

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ABSTRACT. Ground applications of malathion thermal fogs and cold mists were made in 2 rural communities where a few species of yellow fever vectors were co-existing. Malathion thermal fogs (5%) dispersed efficiently in dense vegetation and gave a reduction of more than 90% in the crepuscular landing rate of *Aedes africanus*. However, because the fogs had no residual effect, the population returned to pretreatment levels within 5 days. In contrast, both population reduction and recovery were considerably slower after the 1st malathion cold mist (50% emulsifiable concentrate) application. The 2 successive cold mist applications in a larger community resulted in an immediate and sharp decline (over 95%) in numbers of adult mosquitoes, followed by a 100% reduction in oviposition which lasted for 2 weeks. The population recovery after sequential treatment of malathion cold mists was rather slower in a larger area than in a small community, mainly due to low infiltration of mosquitoes from nearby untreated forest. Cold mists penetrated 40 m into forest from foot-paths where spraying was carried out, more droplets fell in trees at a height of 7 m than on the ground, and more droplets settled naturally than by the effect of blasts from the spray machine.

These trials show that for communities with dense vegetation and undulating terrain ground application of undiluted insecticides using a knapsack Fontan R12 machine is suitable, and that the Fontan R12 is more suitable than the Swingfog machine for areas larger than 15–20 ha. The technique can be used efficiently by locally recruited personnel to suppress the local yellow fever vector population in forested villages with the aim of interrupting virus transmission.

INTRODUCTION

Yellow fever (YF) continues to occur in West Africa with outbreaks exclusively in rural areas (WHO 1971). In wooded communities in the eastern region of Nigeria *Aedes africanus* is the most prevalent potential YF vector. Bang et al. 1979 found that of 19 mosquito species caught landing on man during twilight hours over 90% were *Ae. africanus*. This species not only bites man at both ground and canopy levels but also frequently enters human dwellings for blood meals and oviposition. However, *Ae, africanus* and *Ae. aegypti*, *Ae. luteocephalus* and the *Ae. furcifer/taylori* group, 3 other common vectors of YF, do not remain indoors, and it seems likely that they rest in bushes around human dwellings.

It has been shown that immediate control of mosquito vectors, as well as agricultural pests, can be achieved effectively by ultra-low volume (ULV) spraying of insecticide from aircraft or with ground equipment. In South-East Asia outbreaks of dengue haemorrahgic fever (DHF) were successfully controlled by aerial application of malathion (Kilpatrick et al. 1970); Lofgren et al. 1970). In controlling *Ae. aegypti* in highly populated urban centers, ground application of cold aerosols from vehicle-mounted LECO machines (Pant et al. 1971, Pant et al. 1974) and of thermal fogs (Bang et al. 1972) are equally successful. For aerial application 50% malathion emulsifiable concentrate

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(EC) was as effective as technical grade malathion against DHF in Indonesia (Pant et al. 1974, Unpublished WHO Document; Self et al. 1977).

Aerial ULV application of technical grade malathion was also effective against *Ae. simpsoni*, the vector of YF, in the interior of Ethiopia (Brooks et al. 1970) and in a coastal area of Tanzania against *Ae. simpsoni* and *Ae. aegypti* (Parker et al. 1977). In West Africa malathion applied from an aircraft during a yellow fever epidemic in Angola interrupted transmission by *Ae. aegypti* (Ribaro 1973). However, little is known about the potential of such application methods in wooded environments, and it may be that different techniques are required for use against the vectors of YF in West Africa which rest and breed exclusively in gallery forests in wooded savannah or jungles surrounding villages.

In 1977 and 1978, therefore, the WHO Arbovirus Vector Research Unit in Enugu, Nigeria, carried out a series of trials to assess measures which could be applied against sylvatic vectors of YF in the event of an outbreak in rural communities. The aim of the trials was to identify measures which would temporarily suppress the natural populations of the primary YF vectors, *Ae. aegypti, Ae. africanus* and *Ae. luteocephalus*. This paper describes trials carried out in two wooded communities near Enugu to determine the efficacy of ground applications of malathion using Swingfog and Fontan R12 machines.

TRIAL AREAS

EZAMA-NIKE FOR THERMAL FOGGING AND COLD MISTS. Ezama-Nike (6°28′N—7°30′E) is located approximately 15 km north-east of Enugu and has 140 inhabitants living in 28 compounds over an area of about 20 ha. The village is completely surrounded by savannah grassland and yam and cassava farms. The nearest forest is at a distance of about ½ km. Each compound is well shaded by numerous trees; citrus, mango, banana, pineapple, cocoyam, pawpaw, etc., are abundant. In addition, there are 7 patches of forest relicts within the village.

Since the network of roads and foot-paths is the most important factor in successful ground treatments (Pant et al. 1971), all accessible roads and foot-paths were mapped and measured. The amount of road which could be used for the application of insecticide in Ezama-Nike was 225 m per ha; since application would be from both sides of the road, this gave 450 m per ha.

AWHUM FOR COLD MISTS. Awhum (6°31′N—7°24′E) is located 30 km north-east of Enugu and covers 200 ha. All sides of the village are bordered by grassland except the east where there is a 20-meter-wide gap for an electric power-line. The village consists of spacious compounds of multi-roomed, mud and center-block dwellings situated among low bushes and trees (oil bean, oil palm, Iroko spp., etc.) which form a broken canopy. Located on the edges of the compounds and scattered within clearings are farms of cocoyam, cassava, yam, pineapple and banana/plantain. The village is dissected by a network of foot-paths. Maps were prepared and distances of useable road calculated as in Ezama-Nike (Table 1).

ABOR. Abor village (6°29′N—7°23′E), a wooded community on the Udi Hills similar to the trial villages of Ezama-Nike and Awhum, was used as a control area.

TREATMENTS

THERMAL FOGS. Thermal fogs were used only at Ezama-Nike and were applied using a Swingfog machine.[4] In June 1977 2 applications, 1 week apart, were made of 50% malathion EC diluted to 5% in diesel oil. The amount of 50%

[4] Manufactured by Montan GmbH, D7972, Isny, Federal Republic of Germany. (The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the World Health Organization.)

Table 1. Basic information about the locations used in the trials.

Information	Ezama-Nike	Awhum	Abor (control area)
Locality	6°28′N–7°30′E	6°31′N–7°24′E	6°29′N–7°23′E
Area (ha)	20	200	100
No. of compounds	28	123	75
Population	240	1,188	525
Useable road (m/ha)	225	300	—
No. of containers/compound	10	24	22

malathion used in the 2 applications was 11.5 liters (0.575 liters/ha) and 12.0 liters (0.6 liters/ha).

For each application 2 teams, each comprising 3 spraymen and 1 WHO entomologist, worked together from the southern corner of Ezama-Nike to the northern end. They walked at a speed of about 1 km/hr directing the combustion pipe always to the right-hand side horizontally.

COLD MISTS. Cold mists were used at both Ezama-Nike and Awhum. At Ezama-Nike the 2 thermal fog applications were followed 18 days later, when natural populations of *Ae. africanus* had returned to the pre-thermal fogs level (Table 2), by 3 cold mist applications, 18 days and 2 days apart, of 50% malathion EC using a Fontan R12 machine. The discharge rate was 4.5–5.0 liters/hr, which gave 20 liters in each application (i.e., 1 liter/ha) during a 2-hr period.

The trial village of Awhum received 2 cold mist applications only, 7 days apart, in August 1977 using technical grade malathion and a Fontan R12 machine. The dosage rate was 665 ml/ha. Each team consisted of 3 spraymen, alternating at 30-min intervals, and one supervisor. On the 1st day of treatment, the teams sprayed the central area covering about 65% of the total walking distance. The remaining area was sprayed on the 2nd day. The teams walked at a speed of about 2 km/hr directing the spray nozzle

Table 2. Crepuscular landing rates (per man-evening) of the four most common mosquito species before and after malathion treatment at Ezama-Nike.

Days before or after treatment	*Ae. africanus*	*Ae. luteocephalus*	*Ae. aegypti*[1]	*Ae. taylori gr.*	All vector species combined
7 before initial	4.21	2.00	0.64 (72)	0.54	7.57
0–5 after first fog	1.63	0.17	0.08 (32)	0.29	2.50
0–5 after second fog	2.60	0.27	0.06 (27)	0.27	3.33
7 before first mist	7.42	1.00	0.33 (38)	0.33	9.33
0–5 after first mist	3.04	0.38	0.08 (10)	0.16	4.02
14 before second mist	5.38	0.71	0.38 (18)	0.29	7.17
0–2 after second mist	2.00	0.04	0 (0)	0.13	2.69
0–5 after third mist	1.04	0.02	0 (20)	0.04	1.25

[1] Figure in parentheses is the ovitrap index (%).

always to the left-hand side, held upwards at an angle of over 45°.

GENERAL APPLICATION PROCEDURES. For both thermal fog and cold mist applications locally employed villagers were given 6 hr of training in spraying techniques, comprising walking speed with the machine, the correct angle of discharge and techniques of spraying along forest foot-paths and within compounds. For each application spray teams were used on both sides of roads and foot-paths and on the perimeters of each compound. Walking speed was slightly reduced in the vicinity of forest patches and the angle of discharge was altered in order to spray over high vegetation. All applications took place during afternoon or early evening hours, usually between 13.00 and 20.00 hr, coinciding with the early flight and feeding activities of the main YF vectors in the region and a time of limited wind velocity.

Because of the denseness of the vegetation, the undulating terrain and the lengthy duration of each application, 3 spraymen were alternated on each machine at 30-min intervals. As a result fatigue was minimized and efficiency increased.

EVALUATION

CREPUSCULAR LANDING RATES. Adult collections were carried out by 12 collectors at 6 locations; 2 on platforms 6–8 m high, 2 at ground level near the platforms, and 2 near the compounds. At each station all mosquitoes landing on the collectors' bare legs during a 4 hr period, starting 2 hr before sunset, were collected. Females of *Ae. africanus* were dissected to determine parity using the technique developed by Beklemishev et al. (1959). The pre-treatment female landing rates of *Ae. africanus* and all other arboviral vector species were determined from 2 catches (1 week apart) 2–3 weeks before treatment. Post-treatment densities of the vector population were checked 3–4 times in the 1st week after each application (rain permitting), 3 times in the next 2 weeks, and then weekly until adult densities returned to pre-treatment levels. In the control area of Abor village, bi-weekly collections were made starting 2 months before the treatment period. As natural populations of *Ae. africanus* females fluctuated greatly in the control area, the percentage reduction following treatment was calculated by using the formula $100—100^{P}/P$, where P is the difference in post-treatment landing rates between the treated and untreated areas (treated/untreated) and p is the pre-treatment difference.

OVITRAP INDICES. Twenty-four oviposition traps were set up in pairs near 12 compounds and 24 in forest patches. Paddles were exposed for 2 days and ovitrap indices were calculated for each species on the basis of paddles that yielded larvae through three consecutive soakings as described by Bang et al. 1979.

BIOASSAYS. Adult bioassays were conducted during the 1st thermal fog and and the 2nd cold mist applications in Ezama-Nike, and during the 2nd cold-mist application in Awhum, using paper cups with netting on 3 sides and the top each containing 10 blood-fed *Ae. aegypti* females. Fifteen cups were placed outdoors in compounds, 15 at ground level and 15 on trees at a height of 5 m in and around forest relicts. Ten cups were used as controls.

Larval bioassays were carried out in Ezama-Nike during the 2nd cold mist application using late 3rd and early 4th instar larvae of *Ae. aegypti* to determine whether the cold mist had any larvicidal effect. Three cups, each containing 20 larvae in 100 ml of water, were placed near existing water containers in each of 10 compounds where adults were being monitored, and 4 cups in each of the 7 forest patches. Ten cups were used as controls.

DROPLET DENSITY AND SIZE. To determine the distribution of the cold mists in Awhum, Kromekote cards (5 x 7 cm) for droplet collection were placed in 4 transects from foot-paths at 5, 10, 20 and 40 m, and in 5 compounds. Cards were placed horizontally on the ground, and horizontally and vertically in trees among branches at a height of 7m.

Droplet size was measured using slides coated with magnesium oxide placed horizontally and vertically (10 m from 1.0 nozzle) at ground level and heights of 3.5 and 7 m. The volume median diameter (VMD) was calculated according to the method recommended by WHO (1974).

RESULTS

THERMAL FOGGING (EZAMA-NIKE). *Ae. africanus* was the most prevalent species before and after treatment with insecticide, followed by *Ae. luteocephalus* and *Ae. aegypti* and the *Ae. taylori/furcifur* group (Table 2). Of these 4 species, *Ae. aegypti* and *Ae. luteocephalus* were the ones most effectively suppressed by thermal fogging. The reduction in numbers of *Ae. africanus* was almost 95% on the 1st day after each of the 2 thermal foggings, but the landing rate began to rise on the 2nd day and had returned to pre-treatment levels within 5 days. There was no significant difference in population reduction at the 3 collection sites, but the population recovery rate at the platforms was faster than at ground level both in the forest patches and near the compounds (Table 3).

COLD MIST USING 50% MALATHION EC (EZAMA-NIKE). Both the reduction in and the recovery of *Ae. africanus* populations following cold mist applications were considerably slower than after thermal fog applications (Table 3). Two days after the 1st cold mist application an 85% reduction in the *Ae. africanus* population had occurred. The population reached pre-treatment levels 18 days later. The 2nd and 3rd cold mist applications achieved 91% and 99% suppression respectively.

COLD MIST USING TECHNICAL GRADE MALATHION (AWHUM). Landing rates of *Ae. africanus* were reduced from 9.0 before application to 0.4 per man-evening for 7 days after the 1st application (Table 4). Control of other *Aedes* species was complete during this period except for low numbers of *Ae. furcifer/taylori*.

In general, control in Awhum was more effective than in Ezama-Nike and no mosquitoes were collected on the 1st evening of the 2nd application. Densities of all *Aedes* species were less than 0.5 per man-evening for 10 days after the 2nd application. While densities of *Ae. africanus* increased rapidly after 2 weeks, they did not return to pre-treatment levels until 8 weeks after the 2nd treatment (Fig. 1). As at Ezama-Nike, the crepuscular landing rate of *Ae. africanus* at ground level near compounds was slower

Table 3. Crepuscular landing rates per man-evening of *Aedes africanus* at three different sites in Ezama-Nike after malathion treatment.

Days before or after treatment	Site			
	Platform	Ground	Compound	Combined
Second thermal fog				
2 before	3.75	5.50	2.50	3.92
0 after	1.75	0	0.25	0.67
1 after	0.08	0.08	0.17	0.67
2 after	2.50	1.75	1.25	1.83
5 after	12.50	7.00	3.25	7.58
First cold mist				
7 before	9.75	6.75	5.75	7.42
0 after	3.50	6.50	1.75	3.91
1 after	4.25	0.50	1.25	2.00
2 after	2.25	0.75	1.25	1.42
5 after	6.75	4.50	3.25	4.83

Table 4. Crepuscular landing rates per man-evening of the four most common vector species before and after malathion treatment at Awhum.

Measurement taken	*Ae. africanus*[1]	*Ae. luteocephalus*	*Ae. aegypti*[1]	*Ae. taylori gr.*
Before treatment[2]	9.05 (15.5)	0.08	0.04 (14.1)	0.04
After first cold mist[3]	0.44 —	0	0 —	0.03
After second cold mist:				
first week	0.10 (0)	0	0 (0)	0
second week	0.44 (0)	0	0 (0)	0
fourth week	3.08 (2.9)	0	0.03 (8.7)	0
sixth week	4.47 (5.8)	0.08	0.04 (17.4)	0
eighth week	9.75 (4.6)	0.13	0.17 (9.2)	0

[1] Figure in parentheses is the ovitrap index (%).
[2] Mean of two collections made during one week.
[3] Mean of three collections made during one week.

to reach pre-treatment levels than the rate at the platforms.

PAROUS RATES. Differences in population reduction and recovery after thermal fog and cold mist treatments are most clearly demonstrated in the percentages of parous females (Table 5). In Ezama-Nike, the parous rate declined from 54% six days before the 1st application to 31%

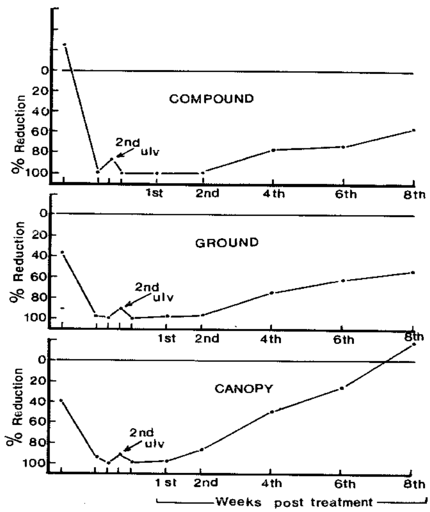

Fig. 1. Percent reduction of *Ae. africanus* caught on human bait at three locations after treatment with Malathion at Awhum.

on the evening of the 1st thermal fog application. It then increased gradually to 71% during the 12 days after application. However, in the 5 days after the cold mist applications the rate declined from 90% to 74%. It then began to increase. The parous rate following the cold mist applications in Ezama-Nike was not below that in the control area where there was an increase from 54% in June to 83% in September. In contrast, the parous rate in Awhum was lower than that in the control area for a 2-week period after the 2nd cold mist application (47–66% compared to 85–88%) (Table 5). There was no significant difference in the parous rate at the 3 catching sites (platform, ground in forest patches and ground near compounds).

OVIPOSITION. The percentage of paddles positive for *Ae. aegypti* declined in Ezama-Nike from 72 to 2.5 for the 2 days (not clearly shown in Table 2) after the 1st thermal fog application and thereafter increased (Table 2). The decline after the 2nd thermal fog application was not as marked as that after the 1st.

The ovitrap indices for *Ae. aegypti* declined further after the cold mist treatment. The effect of the cold mist treatment on oviposition was highlighted at Awhum where no positive paddles were collected for a 9-day period following the 2nd cold mist application (Table 4). The *Ae. aegypti* index began to increase during

Table 5. Parous rates of *Ae. africanus* females caught before and after malathion treatment at Ezama-Nike and Awhum[1].

Ezama-Nike		
Days before or after treatment	Fogging with malathion EC	Cold mist with malathion EC
6 before	54.2 (54)	72.2 (71)
0 after	30.8	89.9
1 after	50.0	84.4
2 after	51.2	81.5
5 after	64.0	73.5
12 after	71.0 (69)	90.2
18 after	—	91.1 (83)

Awhum	
Week before or after treatment	Cold mist with technical grade malathion
1 before	89.6 (88)
1 after	66.0
2 after	47.1
4 after	74.2 (85)
6 after	82.1 (67)
8 after	85.0 (86)

[1] The number in parenthesis is the rate in the control area during the same period of time.

the 4th week after the 2nd application. However, the *Ae. africanus* index remained below 6% for 8 weeks following the 2nd cold mist application.

BIOASSAYS. In both kinds of treatment at Ezama-Nike (5% malathion thermal fogs and 50% malathion cold mists) adult bioassays showed 100% adult mortality, even in trees at a height of 5 m (Table 6). The mortality recorded immediately after thermal fog applications was slightly higher than that immediately after cold mist applications. Unlike the adult bioassay, the initial larval mortality was nil and the count after a 24-hr holding period was also very low (70–90%) especially in containers which had been placed in the forest to simulate treeholes.

Adult mortality rates recorded in Awhum after applications of technical grade malathion were greater than 90% at ground level but only 57% at a height of 5 m (Table 6). Twenty-four hours later mortality rates were greater than 96% at all sites.

DROPLET DENSITY AND SIZE. Mean droplet densities determined from Kromekote cards placed horizontally on the ground were between 0.5/cm^2 and 9/cm^2 (Table 7). In general, cards placed

Table 6. Percentage mortality of *Ae. aegypti* adults and larvae exposed in different locations to malathion thermal fog and cold mist applications.

			Location			
				Forest patches		
Stage	Treatment	Mortality read	Compound (outdoors)	Ground level	At height of 5 m	Control
Adult	Thermal fog	Immediately	84	100	100	0
		After 24 hr	100	100	100	6
Adult	Cold mist with malathion EC	Immediately	78	95	93	0
		After 24 hr	100	100	100	4
Adult	Cold mist with technical grade malathion	Immediately	99	97	57	0
		After 24 hr	100	100	96	5
Larvae	Cold mist with malathion EC	Immediately	0	0	—	—
		After 24 hr	91	69	—	0

Adult: ten blood-fed females per cage in 15 replicates.
Larvae: twenty late third or early fourth instar larvae per cup in 30 replicates.

Table 7. Mean droplet density (number of drops/cm², mean of five cards) of technical grade malathion sprayed from a Fontan R12 machine using a 1.0 nozzle.

		Location					
		Transect from nozzle in forest					
Level	Card position	5 m	10 m	20 m	40 m	Compound	Garden
Ground	Horizontal	2.2	3.1	0.9	0.5	9.0	7.0
7 m high in	Horizontal	12.1	8.3	1.6	0.7	26.7	3.5
trees and	Vertical	1.5	0.9	0.1	0.1	16.7	4.4
among branches	Underneath branches	0.0	0.0	0.0	0.0	1.3	0.1

horizontally in compounds and gardens received more droplets than those placed in transets from foot-paths to forests, whether they were positioned on the ground or in branches at a height of 7 m. However, in the transets a higher droplet density was found on the cards placed horizontally in trees at a height of 7 m than on those at ground level. This was probably due to the fact that the spray nozzle was always directed upwards. The cards positioned vertically in forests at a height of 7 m had a lower droplet density, as did those placed underneath branches.

Table 8 shows the volume median diameter (VMD) of technical grade malathion applied at a rate of 4.3 l/hr from a distance of 10 m using a 1.0 nozzle. The VMD ranged from 113 microns (μm) to 118 microns. The difference in the VMD of droplets on slides placed at ground level and heights of 3, 5 and 7 m was less than 5%. The difference in VMD on slides placed vertically and horizontally was even lower, about 1%. The VMD of droplets of malathion EC ranged from 45 to 98 microns.

TOXICOLOGY. During the entire trial period no complaints were made by either the residents of the 2 treated areas or the locally employed spraymen.

DISCUSSION

These trials indicate that densities of *Ae. aegypti, Ae. africanus* and other vectors of YF in wooded rural communities in eastern Nigeria can be rapidly reduced by the application of malathion from foot-paths using portable equipment such as Swingfog or knapsack Fontan R12 machines.

Thermal fog applications of 5% malathion EC effectively penetrated heavy vegetation (including canopy) and engulfed the entire trial village. A reduction of more than 90% in both sylvan and peridomestic landing densities of *Ae. africanus* was achieved by each thermal fog application. In addition, the oviposition activity of *Ae. africanus* and *Ae. aegypti* was interrupted for 5 days after the 2nd thermal fog application. However, the thermal fog applications had no residual

Table 8. Volume median diameter in microns of malathion droplets sprayed from a Fontan R12 machine at a distance of 10m using a 1.0 nozzle and a dosage rate of 4.3 l/hr.

	Vertical cards		Horizontal cards	
Height	Technical grade malathion	Malathion EC	Technical grade malathion	Malathion EC
0.2 m	116.0	98	114.0	95
3.5 m	118.0	55	117.0	80
7.0 m	112.5	49	113.5	65

or cumulative effect and re-infestation occurred in less than 1 week.

It appears that complete elimination of *Ae. africanus* is not possible with 2 thermal fog applications of 5% malathion from the ground. This may be due to the forest patches in and near Ezama-Nike and a failure to reach canopy populations of this most important vector of YF. It is suggested that at least 3 thermal fog applications with 5% malathion at 3–5 day intervals are necessary if natural populations of this vector are to be reduced quickly and with effect for 10–14 days in order to interrupt virus transmission.

The first cold mist application was less effective than the 1st thermal fog application in suppressing *Ae. africanus* and other vector species but the density recovery rate following the cold mist application was slower than that following the thermal fog applications. Successive cold mist applications gave greater control and had a prolonged cumulative effect on both crepuscular landing rates and oviposition. In part however this is due to a larger droplet size (Table 8) and more effective penetration of dense vegetation (Table 7).

Average droplet densities as determined from cards positioned horizontally and vertically in forests demonstrated good penetration even in the horizontal position at heights of 7 m. Droplet density at higher levels on horizontally placed cards is important when considering the natural biting behavior of *Ae. africanus* at canopy levels. A higher droplet density on cards placed horizontally indicates that the wind and blasts from the machine were less crucial for impingement than the natural settling effect of gravity. This was evident at distances of up to 40 m. The bioassay mortality data also revealed evidence of the penetration of malathion into vegetation.

The 50% malathion EC cold mists applied in Ezama-Nike had less impact on *Ae. africanus* (Table 3) than the technical grade malathion applied in Awhum (Table 4). This is probably due to the smaller area of Ezama-Nike, which permitted infiltration of mosquitoes from adjacent untreated areas; *Ae. africanus* is known to have a flight range of about 3 km over 4–8 days (Germain et al. 1972). Thus, parous rates remained high even after the 2nd and 3rd applications.

In treating forest communities, because of the nature of the compounds and their inaccessibility, the flexibility and maneuverability of knapsack sprayers are important advantages, and in dealing with an epidemic they would be essential. The Fontan R12 machine was found to be more suitable than the Swingfog machine for covering areas greater than 15–20 ha. Breakdowns were common and good general maintenance and routine service at the end of each working day were found to be essential. It is recommended that a trained mechanic be present during each application if a strict spray schedule is to be adhered to. Although the performance of the machines was acceptable it would be preferable to have a lighter, quieter machine which vibrates less.

The trials showed that locally recruited and trained spraymen could work at the level required for the State Ministry of Health malaria teams.

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