MICROENCAPSULATED FORMULATION OF MALATHION FOR CONTROL OF *AEDES SOLLICITANS* [1]

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ABSTRACT. Microencapsulated formulations (MEF) of malathion and Sumithion® were compared to malathion ULV for efficiency in controlling adult *Aedes sollicitans* (Walker), and the levels of malathion residues on vegetation and in soil were determined. Control of mosquitoes was greater and lasted longer in fields treated with the microencapsulated formulations. Within the 48 hr after application, malathion residues on vegetation in the MEF field were 2.3–2.6X those in the ULV field. In soil the residue difference was 2.7. The correlation between depression of mosquito populations and the residual life of MEF warrants further research.

INTRODUCTION

It has been approximately a decade since residual insecticides were used for adult mosquito control in the United States. Most mosquito control agencies phased out the use of DDT long before its restriction (Ruckelshaus 1972) to disease control programs. Without residual insecticides, adulticiding has relied mainly on the technique of applying ultra low volume (ULV) insecticides, wherein airborne droplets are intended to impinge on the flying mosquito. The efficiency of ULV depends on many factors, not the least of which is that the mosquito should be active in order to contact the aerosol droplet. This presents a problem of timing of the application since most species have 1 or 2 peaks of activity (Clements 1963) but for most of the 24 hr day are resting or only intermittently active. Such is the general pattern of activity of the salt marsh mosquito, *Aedes sollicitans* (Walker). On emergence from the breeding sites on the salt marsh, this species in a few days moves a short distance inland and seems to congregate at first in small fields surrounded by woods. During the day, the adults remain in the grasses and low woody growth, becoming intensely active at dusk and into the 1st hr of darkness. The latter is an impractical and unsafe time for aerial ULV application. The species becomes active again at dawn, when wind conditions often can cause excessive drift of aerosol droplets.

Because of the complexity of the ULV control strategy, we recently decided to develop an alternate strategy directed at controlling mosquitoes in the fields in which they rest during the day. A new formulation procedure, the microencapsulation of insecticides (Pennwalt Corp., U.S.A.), has recently been developed. The polymer capsule wall regulates the release of the insecticide, the rate being dependent on the chemistry of the capsule wall. One such insecticide, methyl parathion, is trademarked Penncap® and is currently registered for use on certain vegetable crops. In 1976, small amounts of microencapsulated malathion and fenitrothion (Sumithion®) became available for experimentation in *Ae. sollicitans* control. This is a report on the performance of these 2 formulations in comparison with malathion ULV. Also reported are the residual levels of malathion remaining on the vegetation and in the soil of areas treated with ULV and the encapsulated formulation.

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MATERIALS AND METHODS

The three materials, Cythion® (91% malathion) ULV, malathion encapsulated (2 lbs. AI/gallon, 240 g AI/1) and Sumithion® encapsulated (2 lbs. AI/gallon, 240 g AI/1) were applied by two Bell 47 G4 helicopters, one equipped with a Beecomist® nozzle model 350 (Beeco Products Co., Fort Washington, Pa.) for malathion ULV, and the other with a series of nozzles calibrated to deliver the encapsulated materials diluted in water at 4 gal per acre (18.69 1/ha). Working swath for the ULV Cythion (3 oz./acre) was 200 ft. (60 m), for the encapsulated formulations 50 ft (15 m). Helicopter altitude was 20–30 ft (6.1–9.1 m) and air speed 45–50 mph. The amount of actual insecticide applied was comparable in all cases, 0.24 lb AI/a (0.27 kg AI/ha). Applications were made shortly after 8 a.m., with Kytoons® and Day-glo® panels as guides for application. During the study, no measurable precipitation occurred. Temperatures at 7 a.m. and 7 p.m. were 14.4–28.9C.

The insecticides were applied to 4 fields measuring approximately 400 ft^2 (37.2 m^2) in Ocean County, New Jersey in August 1976. One-minute landing counts were determined in the center of these fields; vegetation and soil samples were collected at stations established at 50 ft (15 m) intervals across the fields. For each sampling, vegetation taller than 1 in. (2.5 cm) was cut from 0.25 m^2, immediately stored with dry ice and returned to the laboratory within 2 hr for initiation of extraction. Soil samples were returned to the laboratory and frozen within 2 hr pending subsequent analysis. Malathion was analyzed by methods previously described (Boyd 1972), with methylene chloride as extraction solvent. Recovery range was 95.6–97.3%. Residue data were subjected to ANOVA.

RESULTS AND DISCUSSION

The number of mosquitoes landing per min in the 3 treated fields and 1 untreated field in the experiment are shown in Fig. 1. Landing counts (mosquitoes landing per minute, M L/min) were taken at 12 hr intervals (7 a.m., 7 p.m.), the 1st being ½ hr before the insecticide application on day 1. Timing of the experiment coincided with the emergence of a large brood of mosquitoes and their movement into the fields. In the untreated field (control), the population level decreased within 24 hr and remained at 40–60 M L/min for the next 5 days, followed by a further decrease. In the 3 treated fields, populations also decreased by the 3rd day, but to a level at least ½ that in the untreated field. Therafter, the population level in the ULV field remained relatively constant, while levels in the fields treated with the encapsulated formulations continued falling. No adulticide differences could be detected between the encapsulated formulations of malathion and Sumithion®.

On 4 evenings, indicated in Fig. 1 by letter M, a municipal ground ULV machine entered the 2 encapsulated-treated fields and applied malathion. According to the operator's description of his operation, these applications were very incomplete treatments of the fields, and malathion was applied at much less than 0.036 lbs/acre (0.0405 kg/ha). It has been our experience that malathion initially stimulates mosquito activity and that there is a delay of up to 12 hr before a reduction of population levels can be detected. Based on this observation and the variation in mosquito activity during the experiment, we believe that the contribution of the ground ULV applications to the depression of mosquito populations and to the malathion residues detected was minimal.

The reduction in mosquito populations is correlated with the malathion residues from aerial ULV and encapsulated treatments (Table 1); residue levels were higher and populations lower in the field treated with encapsulated malathion. The density of the vegetation was somewhat variable and, therefore, residues are reported both as ppm (parts per million) and as mg/vegetation/0.25m^2. The latter figure is valuable for comparison with the theoretical amounts that would be found if uniform impact of the malathion (6.5

mg/0.25m²) on the vegetation had occurred. Some malathion residues on vegetation and soil were present before the application. These were probably the result of previous ULV aerial applications for mosquito control in the areas. At 1 hr after the application, malathion residues on vegetation/0.25m² had increased, those in the encapsulated field being 2.6 times greater than those in the ULV field. This was expected since ULV droplets are so small that many drift before impingement. The malathion residues decreased during the next 48 hr, at which point those in the encapsulated field were 2.3 times those in the ULV field. At 48 hr, residues in the encapsulated field were about equal to those in the ULV field 1 hr after appli-

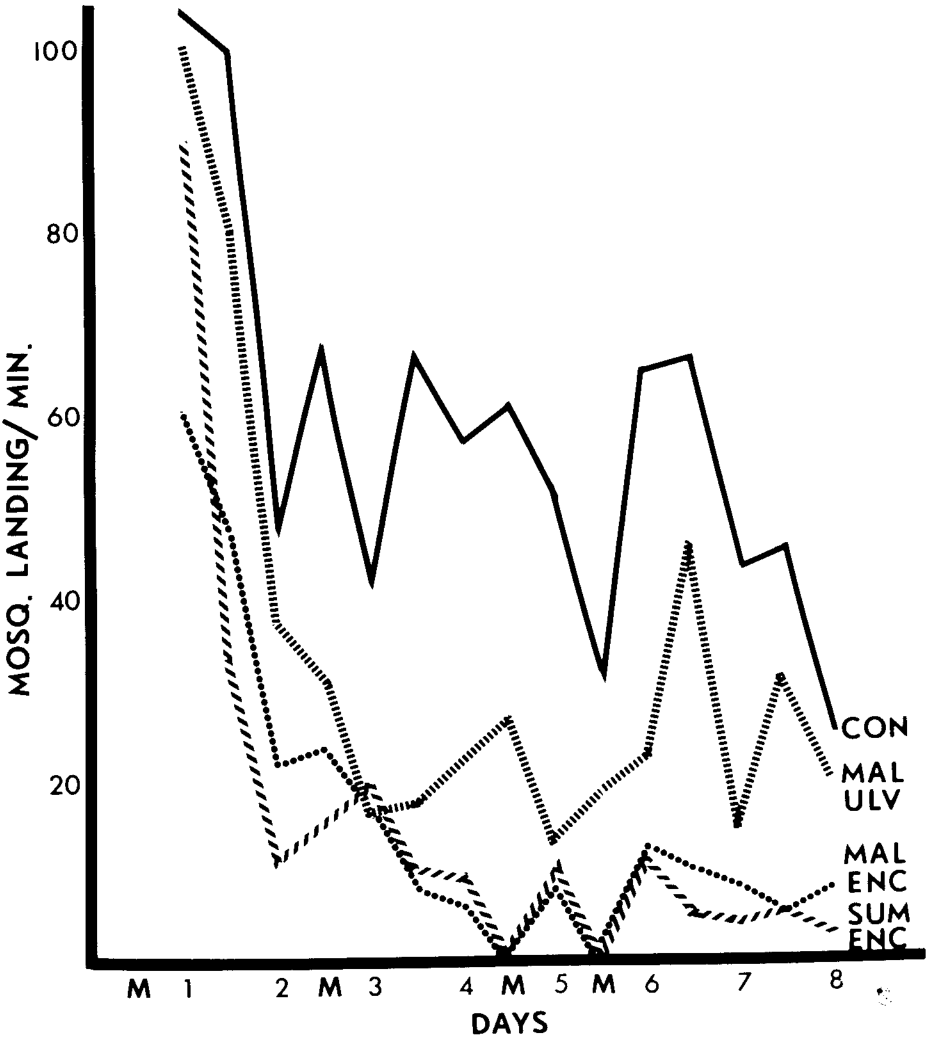

Fig. 1. Mosquito landing counts (12 hour intervals) in fields treated with malathion ULV, malathion encapsulated, and Sumithion encapsulated. Treatment 0.5 hour after day 1; con-control.

Table 1. Malathion residues on vegetation and in soil of fields treated with malathion ULV and encapsulated malathion ($\bar{x} \pm$ SE).

Time	Malathion ULV			Malathion Encapsulated		
	Vegetation		Soil	Vegetation		Soil
	ppm	mg/0.25m²	ppm	ppm	mg/0.25m²	ppm
prespray	5.36 ± 2.27	0.42 ± 0.19	0.000 ± 0.000	2.32 ± 0.62	0.09 ± 0.02	0.012 ± 0.040
spray + 1 hr	18.99 ± 9.21	1.12 ± 0.56[a, c]	0.039 ± 0.018[d]	31.48 ± 9.93	3.01 ± 0.86[a, c]	0.087 ± 0.005[d]
spray + 24 hr	11.97 ± 3.97	0.99 ± 0.28	0.028 ± 0.008[e]	21.38 ± 1.45	1.41 ± 0.15	0.075 ± 0.011[e]
spray + 48 hr	7.02 ± 0.60	0.55 ± 0.15	0.024 ± 0.005[b, f]	16.48 ± 1.39	1.29 ± 0.07	0.081 ± 0.018[b, f]

Means followed by same superscript significantly different at 5% level; for a, b, prespray data included; for c, d, e, f, prespray data not included.

cation. While only the difference in levels at 1 hr after application was significant (P=0.05), we believe the persistence of malathion residues in the encapsulated field was responsible for the extended depression of mosquito populations in that field. The variability of residues on vegetation in the fields prevented further statistical support of this opinion.

The low levels of malathion soil residues in treated fields were not unexpected. Vegetation was sufficiently dense to prevent droplet impact on the soil surface, even with the delivery volume of 4 gal/acre (18.69 l/ha) employed in the encapsulated malathion application. Encapsulated residue levels overall were 2.7 times greater than those of ULV. The rate of disappearance of soil residues in the encapsulated field seemed to be slower than that in the ULV field, presumably due to the protective coating of the capsule. Seven months after application, malathion residues in the soil were not detectable. Based upon maximum theoretical amounts that could have impinged on vegetation and soil, only 46.3% did so in the encapsulated malathion field and 17.8% in the ULV malathion field. Various factors are known to influence impingement (Von Rumker et al. 1975). A more efficient deposit of encapsulated malathion was anticipated in our studies. One aspect for further study in developing a control strategy with encapsulated materials would be the increase of efficiency in delivery to vegetation. Possibly evening applications and less water as a diluent might partially accomplish this. It should be noted also that available methodology may not fully extract the insecticide within the microcapsule and its wall. While the current study has been limited because of the availability of the microencapsulated formulations, the results do indicate that these formulations are worthy of additional examination. In the current study the insecticides were used at the dosage rate currently employed for malathion ULV. Possibly higher rates of application would extend the interval of the effectiveness of encapsulated formulations in controlling adult mosquitoes.

ACKNOWLEDGMENT

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A TRAILER-MOUNTED INSECTICIDE MIXING-LOADING UNIT [1]

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ABSTRACT. Research and small operational applications to study efficacy of pesticides applied by air or ground application equipment are frequently jeopardized by the use of poorly designed, ineffective mixing equipment. The result is the application of a badly mixed and frequently contaminated formulation. A trailer-mounted mixing-loading unit capable of handling suspensions, emulsions and solutions is described. The mixing tank is fitted with a paddle agitation and recirculation mixing system, can be readily cleaned, and has accurate metering of formulation. It is a self-contained system for power supply. An extra tank to hold clean solvent permits quick cleaning of the plumbing to prevent cross-contamination of the test batches of material.

Experimental and operational application of pesticides, whether by ground apparatus or aircraft is frequently troubled by the lack of a suitable system for accurately formulating and dispensing single or repeat batches of material. In too many cases the insecticide is mixed using a temporary arrangement of tanks, hoses, meters, measuring containers and odd pieces of wood (to serve as mixing paddles). These are awkward to handle, lead to inaccuracies in measurement, result in badly mixed formulations, and present a potential for contamination from drips and leaks of material. Another problem arises when different formulations or different insecticides are being tested; in these cases it is important that the plumbing and tanks be cleaned of all residues to prevent cross-contamination. When working in the field, there is the problem of carrying the numerous items required when mixing and handling insecticides. These include safety gear (respirators, hard hats, protective clothing, cleaning material) radio, tools, measuring containers, funnels, small bottles (to take samples of formulated material for chemical standards), hoses, couplings, as well as the many other bits and pieces that are always necessary.

The unit described in this publication is

[1] Presented at the New Orleans meeting, March 1977.