LABORATORY AND FIELD TESTS COMPARING
FORMULATIONS OF MALATHION/RESMETHRIN
WITH MALATHION FOR THE CONTROL
OF ADULT MOSQUITOES

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ABSTRACT. Laboratory and field tests
were conducted to determine the relative ef-
fectiveness of malathion-resmethrin mixtures
and malathion only. Laboratory tests con-
ducted with malathion susceptible species
showed a slight increase in effectiveness of a
90:1 malathion-resmethrin formulation over
malathion for Culex nigripalpus, but not with
Aedes taeniorhynchus. With malathion resistant
Ae. taeniorhynchus, there was no significant dif-
ference between the 100:1 malathion-
resmethrin formulation and malathion.

In the field tests, both technical and dilute
formulations were used in tests against Cx. ni-
gripalpus, Cx. quinquefasciatus and Ae.
taeniorhynchus. These tests showed no dif-
ference in mortality between any of the
malathion-resmethrin formulations used and
malathion, but indicated that the differences in
mortality obtained were dependent on the ac-
tual amount of malathion discharged regard-
less of the addition of resmethrin.

This research was prompted by several
unpublished reports of increased kill of
both susceptible and resistant mosquito
species with various formulations of
malathion and resmethrin as compared to
malathion when applied as ULV ground
aerosols. Although most reports were
rather poorly documented and included
little or no data comparing the degree of
kill obtained with or without resmethrin,
they did indicate a good kill of adult mos-
quitos with malathion-resmethrin for-
mulations.

To evaluate the effectiveness of
malathion-resmethrin formulations, the
following controlled laboratory and field
tests were conducted in 1979 and 1980
comparing various formulations of
malathion and resmethrin to malathion
only.

METHODS

Laboratory testing procedures con-
sisted of exposing laboratory reared adult
mosquitoes in 6 inch diam. screen cages,
each containing ca 25 female mosquitoes,
to 0.5 ml of an acetone solution of the
toxicant in a laboratory wind tunnel. Each
test consisted of exposing duplicate cages
to each of 5 dosages plus a check of
acetone only and 4 to 5 tests were con-
ducted with each toxicant. The LC50 and
LC90 dosages, confidence limits and the
slope and the standard error of the slope of
the dosage-mortality regression line were
obtained by probit analysis of the
data.

Field tests were conducted in the early
evening hours after sunset. Tempera-
tures during the tests ranged from 75 to
85°F and averaged 81.2°F. Wind velocity
ranged from 2 to 8 mph and averaged 5.2
mph. The test plot was a fairly open
beach residential area containing scat-
tered houses, a few large pine trees and
sparse ground vegetation. Four 6 inch
diam cages of mosquitoes, 2 of Culex ni-
gripalpus Theobald and 2 of either Aedes
taeniorhynchus (Wiedemann) or Cx. quin-
quafeasicius Say, each containing ca 25 fe-
male mosquitoes, were attached to a metal
pole. One cage of each species was hung
at 6 ft. and another at 2 ft. above the
ground. The poles were placed at 165
and 330 ft. downwind and perpendicular
to the line of travel of the first swath of
the aerosol generator. A second and third
swath were applied 1 and 2 blocks (300
and 600 ft.) upwind of the first swath.
Each test or replicate consisted of caged
mosquitoes from 3 sets of poles (165 and 330 ft.) placed a block (600 ft.) apart, or a
total of 12 cages of each species.

All field tests were conducted with a
Leco HD® ULV cold aerosol generator at
10 mph. The insecticide tank pressure of
the tests using technical insecticides only
was 4.0 psi, but because of the low viscos-
ity of the formulations with heavy aro-
namic naphtha (HAN), the pressure used
with the HAN formulations was reduced to
1.5 psi. Spraying time was recorded by
a stop watch and the insecticide was mea-
sured before and after each test to deter-
mine output. Actual spray times varied
from 15 to 20 min, depending on the
length of run necessary to completely
cover the test area. Two paired tests, one
with a malathion-resmethrin formulation
and one with malathion only were con-
ducted each night in the same area and
from 2 to 4 of these paired tests were con-
ducted with each formulation. To
avoid bias, the order of the paired tests
was reversed each night.

The mosquitoes used in both the labo-
atory and field tests were from labora-
tory colonies and were between 2 and 8
days old at the time of testing. After
exposure, the mosquitoes were transferred
to clean holding cages and held with ac-
cess to a 10% sugar solution on cotton
pads. Posttreatment mortality counts for
the laboratory and field tests were made
at 24 hrs. and 12–15 hrs., respectively,
except where otherwise indicated. Tests
of the malathion resistant *Ae. taeniorhyn-
chus* were conducted with F₁ adults, the
parents of which were collected in various
areas of the state and shipped to the labo-
ratory. In all tests, the ratio of the
malathion to resmethrin was based on the
weight of active ingredients. In the for-
mulations with HAN, the ratio of
malathion to HAN or malathion to res-
methrin plus HAN was 7:5 by volume.
The malathion formulation used was the
malathion ULV concentrate which con-
tained 91.0% malathion. The resmethrin
formulation used was the SBP-1382
40MF which contained 40.0% resme-
thrin.

RESULTS

The results of the laboratory tests com-
paring malathion-resmethrin at 90:1 and
malathion are shown in Table 1. The data
indicate that there was a slight difference
in the LC₅₀ and LC₉₀ dosages of both spe-
cies favoring the 90:1 malathion-
resmethrin formulation. These dif-
fences, however, were significant with
*Cx. nigripalpus* but not with *Ae.
taeniorhynchus* at the LC₉₀ level.

Shown in Table 2 are the results of the
laboratory tests of malathion resistant *Ae.
taeniorhynchus* comparing malathion-
resmethrin at 100:1 and malathion. From
these data it is apparent that there was no
difference in toxicity between the

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Hours posttreatment</th>
<th>LC₅₀</th>
<th>95% C.L.¹</th>
<th>LC₉₀</th>
<th>95% C.L.¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aedes taeniorhynchus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malathion-resmethrin</td>
<td>4</td>
<td>0.114</td>
<td>0.103–0.126</td>
<td>0.284</td>
<td>0.220–0.366</td>
</tr>
<tr>
<td>Malathion</td>
<td>4</td>
<td>0.113</td>
<td>0.100–0.128</td>
<td>0.348</td>
<td>0.242–0.500</td>
</tr>
<tr>
<td>Malathion-resmethrin</td>
<td>24</td>
<td>0.064</td>
<td>0.057–0.072</td>
<td>0.184</td>
<td>0.149–0.229</td>
</tr>
<tr>
<td>Malathion</td>
<td>24</td>
<td>0.084</td>
<td>0.076–0.092</td>
<td>0.214</td>
<td>0.171–0.267</td>
</tr>
<tr>
<td><em>Culex nigripalpus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malathion-resmethrin</td>
<td>4</td>
<td>0.358</td>
<td>0.320–0.400</td>
<td>1.090</td>
<td>0.893–1.330</td>
</tr>
<tr>
<td>Malathion</td>
<td>4</td>
<td>0.509</td>
<td>0.443–0.584</td>
<td>1.920</td>
<td>1.439–2.563</td>
</tr>
<tr>
<td>Malathion-resmethrin</td>
<td>24</td>
<td>0.276</td>
<td>0.248–0.308</td>
<td>0.774</td>
<td>0.653–0.916</td>
</tr>
<tr>
<td>Malathion</td>
<td>24</td>
<td>0.338</td>
<td>0.286–0.400</td>
<td>1.991</td>
<td>1.400–2.773</td>
</tr>
</tbody>
</table>

¹ 95% Confidence limits.
Table 2. Laboratory adulticide tests of malathion resistant *Aedes taeniorhynchus* from 4 areas of Florida comparing malathion-resmethrin (100:1) and malathion.

<table>
<thead>
<tr>
<th>Area</th>
<th>Insecticide</th>
<th>LC$_{90}$</th>
<th>95% C.L.$^1$</th>
<th>LC$_{90}$</th>
<th>95% C.L.$^1$</th>
<th>LC$_{90}$</th>
<th>RR$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marineland</td>
<td>Malathion-resmethrin</td>
<td>0.84</td>
<td>0.66-1.02</td>
<td>3.68</td>
<td>2.84-4.76</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malathion</td>
<td>0.70</td>
<td>0.54-0.92</td>
<td>3.27</td>
<td>2.29-4.68</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Flagler Beach</td>
<td>Malathion-resmethrin</td>
<td>1.23</td>
<td>1.00-1.51</td>
<td>4.19</td>
<td>3.11-5.64</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malathion</td>
<td>1.74</td>
<td>1.44-2.09</td>
<td>4.33</td>
<td>3.20-5.87</td>
<td>39</td>
<td></td>
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<tr>
<td>Rusk</td>
<td>Malathion-resmethrin</td>
<td>0.63</td>
<td>0.42-0.95</td>
<td>5.54</td>
<td>2.43-12.60</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malathion</td>
<td>0.46</td>
<td>0.27-0.80</td>
<td>6.08</td>
<td>0.98-37.82</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Picnic Island</td>
<td>Malathion-resmethrin</td>
<td>2.04</td>
<td>1.78-2.33</td>
<td>8.62</td>
<td>6.83-10.90</td>
<td>86</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malathion</td>
<td>2.86</td>
<td>2.48-3.31</td>
<td>9.64</td>
<td>7.69-12.08</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>Lab colony</td>
<td>Malathion-resmethrin</td>
<td>0.033</td>
<td>0.48-0.59</td>
<td>0.10</td>
<td>0.09-0.11</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Malathion</td>
<td>0.069</td>
<td>0.65-0.73</td>
<td>0.11</td>
<td>0.10-0.12</td>
<td>—</td>
<td></td>
</tr>
</tbody>
</table>

$^1$ 95% confidence limits.

$^2$ Resistance ratio = \( \frac{\text{LC}_{90} \text{ of resistant strain}}{\text{LC}_{90} \text{ of susceptible lab strain}} \)

malathion-resmethrin formulations and malathion with any of the resistant populations.

The results of the field tests of ULV sprays applied by ground equipment comparing various formulations of malathion-resmethrin and malathion are shown in Table 3. The percent mortalities for the 3 species indicate that there was no difference between any of the malathion-resmethrin formulations and malathion at any of the discharge rates. It is worthy of note, however, that the kill obtained with *Cx. nigripalpus* was proportional to the actual amount of malathion discharged regardless of the formulation or the content of resmethrin. The percent mortality was evidently too high for this effect to be apparent with *Cx. quinquefasciatus*.

Table 3. Mortality of caged adult *Culex nigripalpus*, *Cx. quinquefasciatus* and *Aedes taeniorhynchus* exposed to various formulations of malathion and malathion-resmethrin applied as ULV aerosols by ground equipment.

<table>
<thead>
<tr>
<th>Formulations</th>
<th>Ratio mala:res wt/wt AI</th>
<th>Discharge in fl. oz./min.$^3$</th>
<th>Average percent mortality$^4$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ratio v/v</td>
<td>total</td>
<td>mala</td>
</tr>
<tr>
<td>Malathion-HAN</td>
<td>7:5</td>
<td>4.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Mala-res-HAN</td>
<td>7:5</td>
<td>4.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Malathion</td>
<td>—</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Malathion-resmethrin</td>
<td>—</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Malathion-HAN</td>
<td>7:5</td>
<td>3.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Mala-res-HAN</td>
<td>7:5</td>
<td>3.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Malathion</td>
<td>—</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Malathion-resmethrin</td>
<td>—</td>
<td>1.4</td>
<td>1.4</td>
</tr>
</tbody>
</table>

$^1$ Mala = malathion, res = resmethrin, HAN = heavy aromatic naphtha.

$^2$ Ratio of malathion to HAN or malathion to resmethrin plus HAN (v/v).

$^3$ Total = discharge of total formulation; mala = discharge of malathion portion of formulation only.


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DISCUSSION

This research was prompted by reports of increased kill of both susceptible and resistant mosquito species with the addition of small amounts of resmethrin to malathion and was initiated to test this hypothesis. The results obtained indicate a small but detectable increase in toxicity of malathion-resmethrin formulations in the laboratory against Cx. nigricalpus, but no difference between formulations of malathion-resmethrin and malathion only could be demonstrated in the laboratory against malathion susceptible or resistant Ae. taeniorhynchus or in the field against Cx. nigricalpus, Cx. quinquefasciatus or Ae. taeniorhynchus. In retrospect, however, there appear to be sound reasons for its failure. The lack of effectiveness of resmethrin against Ae. taeniorhynchus, shown in previous testing (Boike and Rathburn 1975; Rathburn and Boike 1972b, 1972c, 1975, 1976; Rathburn et al. 1978), indicate that the addition of very small amounts of resmethrin to malathion would be of no value. Although resmethrin has been shown to be very effective against Culex spp., the addition of the very small amounts of resmethrin to malathion would also be of little value, since malathion has been shown to be considerably less effective against Cx. nigricalpus than against Ae. taeniorhynchus (Boike and Rathburn 1975; Rathburn and Boike 1972a, 1972b, 1972c, 1975, 1977; Rathburn et al. 1964, 1965). Although mosquito species other than those tested here may react differently to the mixture, and different mixtures may possibly show some increase in effectiveness, the increased cost of the mixtures would necessitate obtaining satisfactory control of the target species with a substantial reduction in discharge rates to be economically beneficial.

References Cited


