# LARGE SCALE FIELD TESTS AND ENVIRONMENTAL ASSESSMENTS OF SUMITHION® (FENITROTHION) AGAINST ADULT MOSQUITOES IN GRAND CAYMAN, WEST INDIES

M.E.C. GIGLIOLI[1], E. J. GERBERG[2] AND R. G. TODD[1]

ABSTRACT. Fenitrothion was tested against high density populations of mosquitoes under tropical conditions of wind and temperature. Aerial ULV applications of aqueous solutions were more effective than oil based sprays and the smaller transient droplets not only preclude oil pollution, but also lessen the chances of heavy localized residues of insecticides. With high density mosquitoes, 142 gm/ha gave a near perfect measure of control. Non target insects were affected, however the effect on other aquatic organisms was not significant.

## INTRODUCTION

The results reported herein are part of continuing longitudinal studies conducted by the Mosquito Research and Control Unit in Grand Cayman, to assess aerial applications of insecticide concentrates and their ULV/HD solutions against adult pest mosquitoes. The mangrove breeder, *Aedes taeniorhynchus* is the main target species, and thus all applications were made through high and dense mangrove forests under tropical conditions.

The special validity of these results rests in the fact that all tests have been made over large areas under operational conditions and assessed by their effect on natural infestations on successive nights. Only non-target animals have been given unnatural exposures (in small containers across the swath) in part for convenience and in part to maximize their contact with the insecticide.

## METHODS

APPLICATIONS. All airsprays were done by a Rockwell S-2R Thrush Commander fitted with six Micronair AU 3000 atomizers, with long twisted blades (39.3 cm diameter). The blades were set at 25–30° angle on the outboard and 45° on the inboard atomizers to give maximum r.p.m. and finest atomization. Typically they were operated at a pressure of 40 p.s.i. (2.8 bar) with restrictor No. 8 (2.65 mm orifice) used for a delivery of 365 ml/ha over a 274 m. swath width, or restrictor No. 7 (2.4 mm orifice) for a delivery of 731 ml/ha over a 137 m. wide swath.

All formulations were mixed immediately before use. Take-off was at sunset and airspray applied coincident with the target insect's peak of crepuscular flight activity. This information was radioed to the aircraft by a ground observer.

## ASSESSMENTS

From a practical operational point of view, a successful adulticidal spray must be able to change an intolerable attack rate to a situation where the observer may, if he so desires, remain shirtless and in total comfort. With quick knock-down insecticides this condition is achieved within 10–15 minutes of spraying; with slower acting chemicals, later the same night, and can be best evaluated next evening provided a large enough area is sprayed when one is dealing with a mobile species.

There is no single consistently reliable method of determining adult densities and thus whenever possible many

[1] Mosquito Research and Control Unit, P.O. Box 486, Grand Cayman, West Indies.
[2] Insect Control & Research, Inc., 1330 Dillon Heights Ave., Baltimore, MD 21228.

methods should be used in both the sprayed and control areas. Routine collections must start the night before spraying (night–1) to give a baseline population on which induced and/or natural fluctuations can be compared.

Three methods of assessing mosquito densities were used in these studies: truck trap, light trap and a Johnson-Taylor trap.

## NON-TARGET ANIMAL EXPOSURES

Common swamp and marine animals were used for environmental assessments by exposing them in containers placed every 23 m. across one or two airspray swath widths.

Jellyfish (*Cassiopea* sp.) corixids (*Trichorixa reticulata*) and notonectids (sp. indet.) were exposed in half-filled 1.2 litre plastic containers; the small crab, *Gecarcinus lateralis,* in square 5 l. plastic containers and the minnow *Gambusia puncticulata,* in 24 l. plastic garbage bins.

Control mortalities with *Gambusia* were very high due to handling and transportation trauma, but this was resolved by placing baited garbage bins in canals *in situ* and attracting the sample of fish into the bin, which entailed no handling. A parallel and more realistic test, compared to the bin exposures was made by exposing fish in garbage bins having two 12 × 12 cm. screen "windows" set in them; each bin was tethered in a canal at each 23 m. station, and remained there for the duration of the test. It was felt that this gave a truer assessment of the aquatic environment than leaving the fish in the same water as in the other method.

## TEST AREAS

All tests were made in two major areas of Grand Cayman; Salt Creek in the west, and North Sound Estates in the centre; in some cases Mid-Island Road, in the centre of the island was used as a control area. Whenever insect populations allowed, Salt Creek and North Sound Estates were alternated as control and test areas.

SALT CREEK. An area of dense mangrove, approximately 1.6 km wide with good access through its ca. 364 ha. provided by the dykes and canals of the *Ae. taeniorhynchus* physical control system. To the north the area is bordered by dry land, to the south a large area has been reclaimed by hydraulic dredging and to the east the swamp ends in a 300 m. wide beach ridge.

Most of the eastern and northern half of this swampy area is of the Black Mangrove, *Avicennia germinans* with a ground cover of *Batis maritima.* At the southern edge of the Black Mangrove the canopy reaches a height of 18–22 m. while in the northeastern and northwestern extremities it is low, not over 3–4 m. in height.

The remainder of the area to the east and southeast is covered by (18–22 m.) mixed Red (*Rhizophora mangle*) and White (*Laguncularia racemosa*) Mangrove, with the odd high Black Mangrove. The eastern and southern littoral is bordered by a deep fringe of high Red Mangrove.

The whole area is flooded through most of the rainy season (July to October) and periodically by high tides or storm surges during the winter months.

NORTH SOUND ESTATES. A marina reclamation bordered to the north by a large lagoon or sound, to the east and west by extensive mangrove swamps and to the south by dry land. The reclamation crosses the mangrove belt which is about 1 km deep.

In order to give defence in depth, sprays in this area usually cover from 1,093 to 1,619 ha. In the unreclaimed part a narrow fringing belt of low pioneer Red Mangrove borders the Sound, backed by high Reds and some Black Mangroves. The latter increase in numbers away from the littoral until the southern perimeter of the swamp is of almost pure stands of high Black Mangrove. In contrast, the dry land to the south is of scrubby savannah, with mainly 2–3 m. high Logwood trees (*Haemotoxylin campecium*).

North Sound Estate swamp area is also

almost totally flooded during the rainy season, with intermittent flooding during the winter, dry season.

## RESULTS OF TESTS AGAINST MOSQUITOES

The Biological Optimum Spray Droplet Size or BOSS of Himel & Uk (1975) for adulticidal sprays against mosquitoes is below 20 $\mu$m diameter.

In order to maximize the availability of BOSS sized droplets in the spray spectrum, M.R.C.U. has concentrated on U.L.V. applications of strong solutions of insecticides, rather than the more usual applications of pure concentrates. In these studies this has been extended by using aqueous solutions.

Rapid evaporation of these solutions should enhance the formation of small droplets reducing them to an effective size for impaction on mosquitoes, furthermore, the substitution of diesel by water in our formulation reduces costs and pollution.

Thus, a diesel solution was used only for Test 1, all other tests were with aqueous ULV applications.

## TEST 1

Sumithion Concentrate applied at 365.5 ml/ha in diesel solution, on 274 m. wide swaths, to yield a theoretical dosage of 133 gm/ha A.1. Airspray flown over North Sound Estates from 7.06–7.44 pm on July 24, 1977.

Although this test shows a drastic decline in numbers in the sprayed area, (night+1 with a total reduction of ca. 90% compared with night-1,) the treatment was not adequate to allow a ground observer (M.E.C.G.) to remain in comfort whilst shirtless at sunset on night+1; thus, by an operational standard the control level was insufficient and this application-dosage and formulation cannot be recommended for the control of high density mosquito populations.

The fact that the main target mosquito was *Culex nigripalpus* (Fig. 3, 74.9%) and not *Ae. taeniorhynchus* (21.5%) is not noteworthy as *Culex* species traditionally require higher dosages. On the other hand, *Cx. nigripalpus* is not a voracious biter, and the discomfort noted by one of us (M.E.C.G.) on night+1 was caused entirely by *Ae. taeniorhynchus*.

NON TARGET EXPOSURES. As would be expected exposed insects, notonectids and corixids, were affected with 98 and 35% mortalities after 24 hours. Exposed crabs, jellyfish and minnows were not affected (Fig. 7). However, it is pertinent to note that during this application many dragonflies (Aeschnidae, *Tricanthagyna septima*) were flying in the area. Within 51 minutes of spraying most of these insects were moribund on the ground, crawling and flying in a drunken manner to the point that after 5 min attraction with a car's headlights we were able to collect 43 dragonflies from a ground area of 15 × 5m. in front of the parked vehicle. Very few dragonflies survived to night+1 after spraying.

## TEST II

Sumithion 8E applied at 731 ml/ha in aqueous solution, on 137 m. wide swathes, to deliver 142 gm/ha A.1. (i.e. slightly higher A.1. than Test 1, but applied in a greater volume of water to enhance the numerical BOSS in the spectrum). This treatment was made over the Salt Creek area from 7.70 to 7.24 pm on 18 August, 1977.

Figures 1 and 2 give the results for this test as assessed by truck trap and a Johnson-Taylor suction trap; Figure 4 gives the pooled results per night per method of collection.

This test dealt mainly with *Ae. taeniorhynchus* (88% of collection) and Figure 4 shows a 98% reduction in the sprayed area on night+1 after treatment. This is operationally satisfactory and allowed complete comfort to the shirtless observer (M.E.C.G.) that night, and was marginally satisfactory (94% reduction) on night+2 of spraying.

NON TARGET EXPOSURES. Notonectid

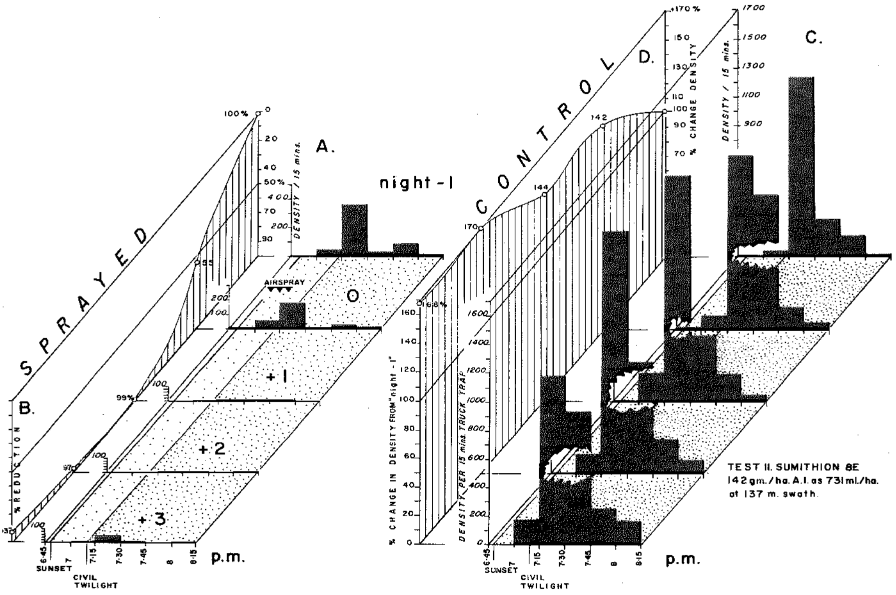


Fig. 1. Truck trap collections.

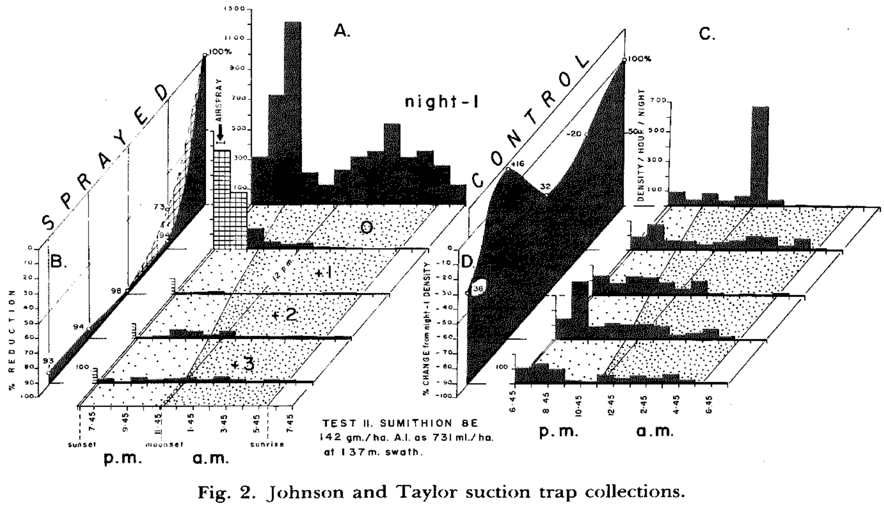


Fig. 2. Johnson and Taylor suction trap collections.

exposures suffered a 95% mortality while crabs and minnows held in the canal bins were not affected. One minnow or 0.5% of the fish exposures held in garbage bins across the swath died (Fig. 7).

## TEST III

Sumithion 8E applied at 731 ml/ha aqueous solution on 137 m. wide swath, to deliver 107 gm/ha A.I. i.e. a lower dose than Test II, with other parameters unchanged. This treatment was made over North Sound Estates on October 11th, between 6.24 and 7.02 pm.

Figure 5 summarizes the results showing an overall reduction of 92% by the night after spraying (night+1); as with

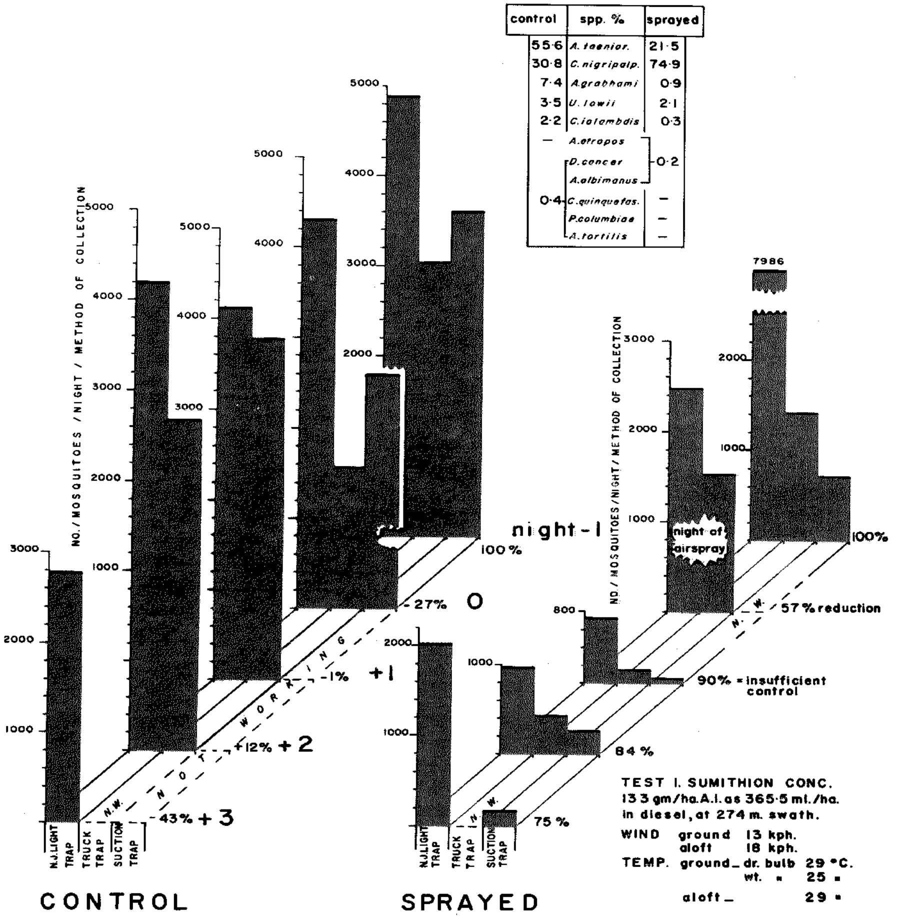


Fig. 3. Results of Test I.

previous results this was an inadequate level of control, and did not give a "shirtless" observer comfort on night+1; thus this dosage cannot be recommended as an operational spray for high density mosquitoes.

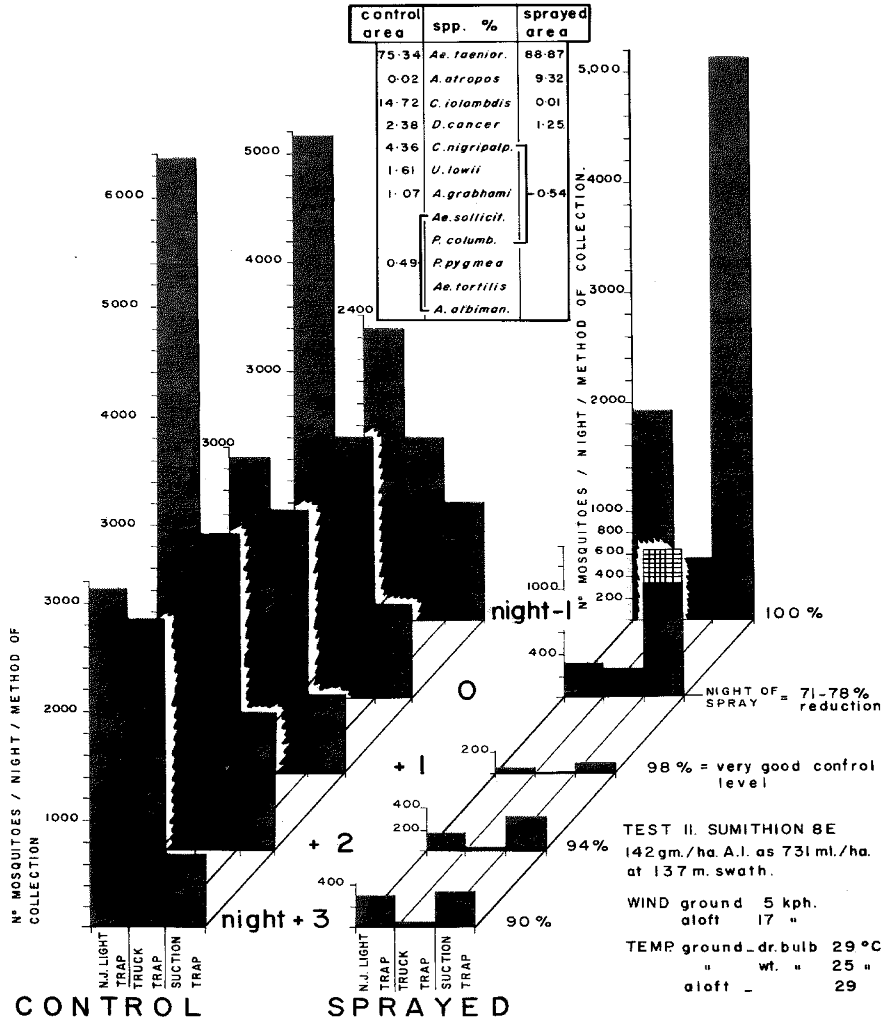


Fig. 4. Results of Test II.

## TEST IV

Sumithion 8E applied at 731 ml/ha aqueous solution on 137 m. wide swath to deliver 69.6 gm/ha A.I. This treatment was made over North Sound Estates on August 23 between 6.54 and 7.35 pm.

Figure 6 summarizes the results showing an overall reduction of 96% by the night after spraying. In spite of the effectiveness of this low dosage as indicated by the suction trap on the night of spray (Fig. 6, night 0) the control level was only marginal on night+1, and did not allow the observer (M.E.C.G.) to go shirtless.

Figure 6 also shows the rapid re-entry into this area on night+2 and night+3, in spite of the fact that a large area (1,093 ha) was sprayed on night 0.

NON TARGET EXPOSURES. This test was

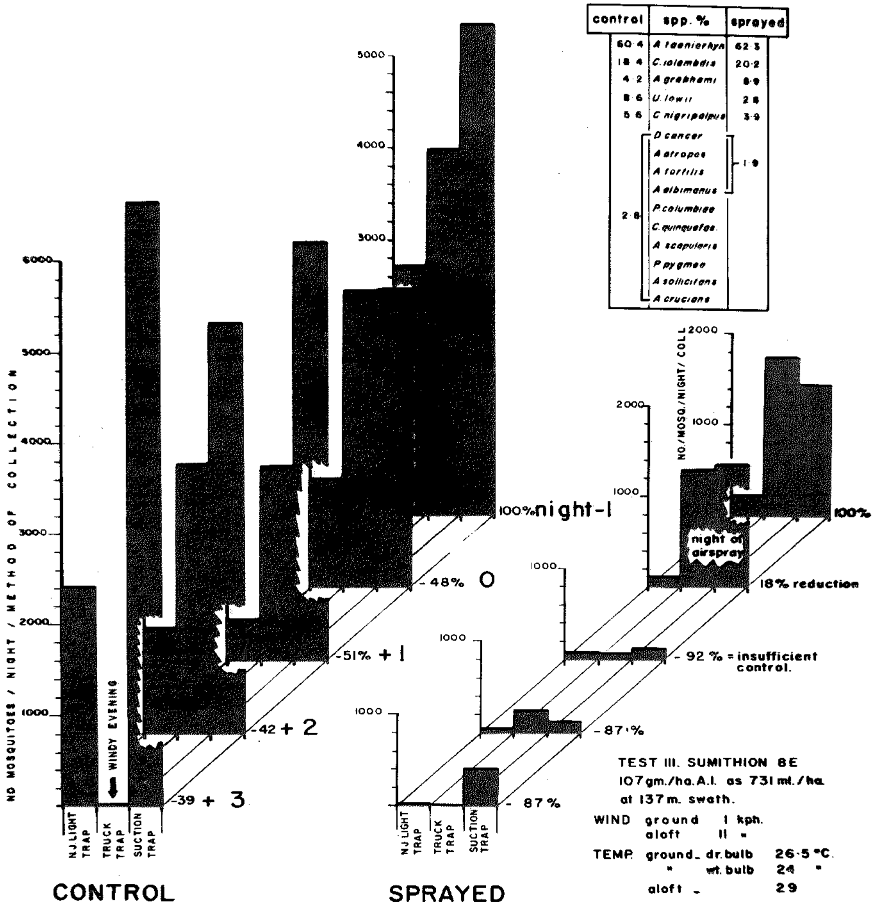


Fig. 5. Results of Test III.

noteworthy for the fact that although many dragonflies (*T. septima*) were present at the time of spraying (as in Test 1), no obvious over-targetting was noticed with this dosage which was 1.9 times lower than that of test 1. In contrast to this, corixid exposures across the swath showed a 46% mortality, crabs were not effected; minnows were not exposed (Fig. 7).

## ENVIRONMENTAL ASSESSMENT

Exposures of non target animals were made with the following treatments:

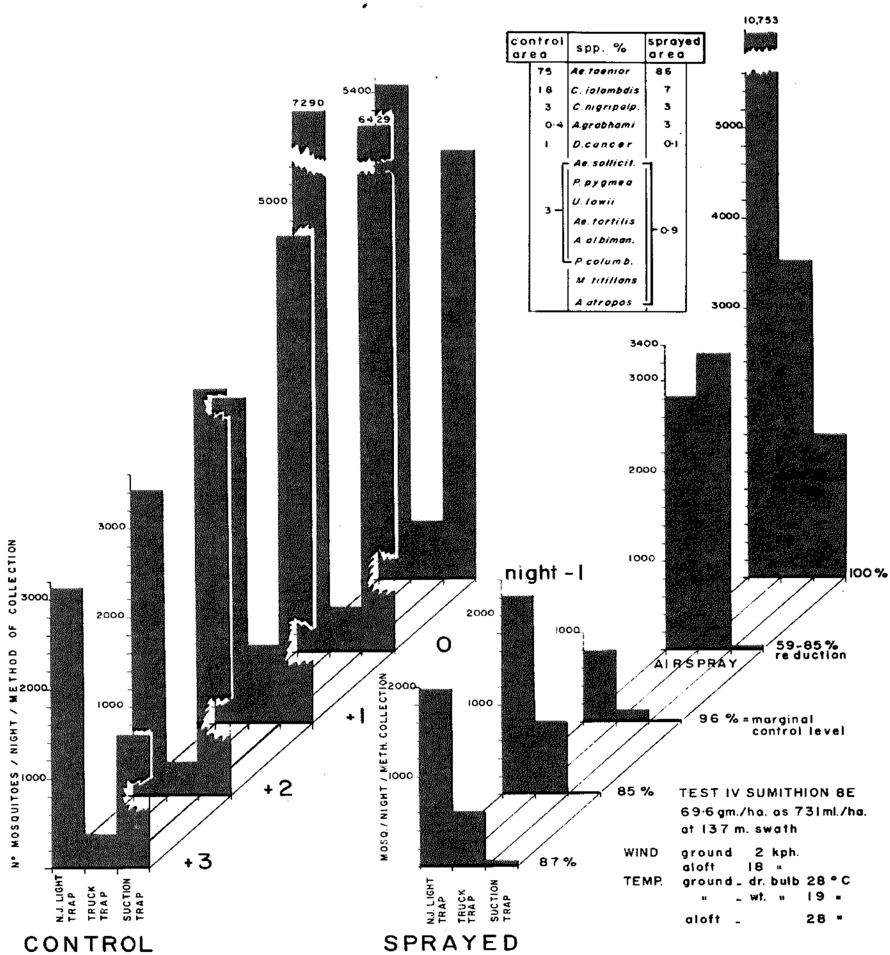


Fig. 6. Results of Test IV.

a. Sumithion Conc. in diesel at 133 gm/ha A.I. (Test 1)
b. Sumithion 8E in water at 142 gm/ha A.I. (Test II)
c. Sumithion 8E in water at 69.6 gm/ha A.I. (Test IV)

Mortalities were observed at 24 and 48 hr after spraying. Further to these routine results, one of us (R.G.T.) visited the swamps daily in connection with longitudinal studies on larviphagous minnows. He was unable to detect any obvious

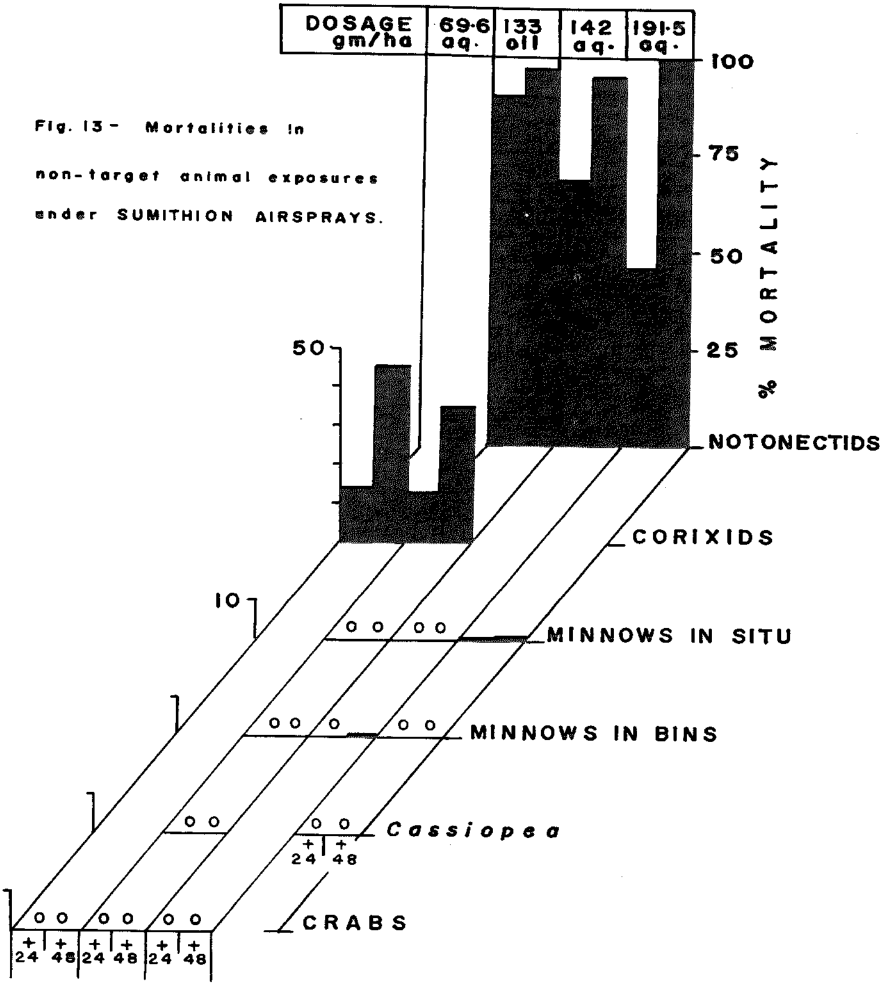


Fig. 7. Mortalities in non-target animal exposures.

sudden trauma or slow change on the swamp's major wild life.

For example, a 1 hr spot census of birds on North Sound Estates was done before Test I (133 gm/ha) and a 3/4-hr census repeated in the morning, 2 days after treatment. The first observation yielded 13 species and the second, 11 species, the differences being consistent with natural fluctuations and the short period of observation.

Figure 7 and Table I give the results of each non target animal exposure under various dosages. It is obvious that aquatic insects such as corixids and notonectids, which depend on captured air films, are highly susceptible and suffer high mortalities. General observations in the swamps and previous tests with other insecticides suggest that no such mortalities would have occurred with siphon breathers, (mosquito larvae) although this was not tested.

Minnows (*Gambusia puncticulata*) showed very low mortalities; 1 and 2% at 191.5 gm/ha and 0.5% at 142 gm/ha, in bin and canal exposures. As explained earlier, the minnows were attracted to the bins by baiting *in situ* and thus the number per bin was variable. It is therefore probable that the observed mortalities were partly due to overcrowding, especially in the *in situ* canal exposures, where low tides tended to concentrate the fish in the tethered bins.

Crabs and jellyfish gave no sign of being affected by the sprays.

## DISCUSSION & CONCLUSIONS

*Ab initio* it should be made quite clear that these tests have been made against high density populations of mosquitoes. Obviously, the higher the target density, the higher the required control level; failing this the survivors will be too

| SPECIES EXPOSED | | | DOSAGE gm/ha. A.I. 69·6 | | 133 | | 142 | | 191·5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | +24hr. | +48hr. | +24 | +48 | +24 | +48 | +24 | +48 |
| NOTONECTIDS *sp. unident.* | | % MORT. | | | 90 | 98 | 69 | 96 | 46 | 100 |
| | | No. EXP. | | | 70 | | 74 | | 69 | |
| CORIXIDS *Trichocorixa reticulata* | | % MORT. | 14 | 46 | 12 | 41 | | | | |
| | | No. EXP. | 35 | | 34 | | | | | |
| MINNOWS *Gambusia puncticulata* | CANAL | % MOR. | | | 0 | 0 | 0 | 0 | 1 | 2 |
| | | No. EXP. | | | 108 | | 127 | | 313 | |
| | BINS | % MOR. | | | 0 | 0 | 0 | 0·5 | 0 | 0 |
| | | No. EXP. | | | 218 | | 220 | | 228 | |
| JELLY FISH *Cassiopea* Sp. | | % MORT. | | | 0 | 0 | | | 0 | 0 |
| | | No. EXP. | | | 9 | | | | 3 | |
| CRABS *Gecarcinus lateralis* | | % MORT. | 0 | 0 | 0 | 0 | 0 | 0 | | |
| | | No. EXP. | 27 | | 27 | | 21 | | | |

TABLE I. MORTALITIES IN NON-TARGET EXPOSURES.

numerous for comfort. It follows that tests against *Ae. taeniorhynchus* are much more demanding than those against lower density pest and vector mosquitoes. Thus a dosage regarded as marginally effective for *Ae. taeniorhynchus* (less than 96% reduction) might yield good control of *Ae. aegypti.*

Table II summarizes the formulations, dosages and the target and nontarget mortalities obtained from 7 airsprays applied over large areas with Micronair rotary atomizers.

Under tropical conditions of wind and temperature at and just after sunset, ULV aqueous solutions are certainly as effective against flying mosquitoes as oil solutions.

Higher levels of control by aqueous, rather than oil-based sprays, appear to be conditioned by an increase in the number of the smallest or BOSS droplot range in the spray spectrum, resulting in multiple impaction on relatively large flying mosquitoes and even on the 3 times smaller sandfly. The use of smaller transient droplets not only precludes oil pollution, but also lessens the chances of heavy, localised residues of insecticides.

In terms of dosages, even with high density mosquitoes, 142 gm/ha A.1. gave a near perfect measure of control.

It is useful to compare the highest dosages used in these tests with those of Nigam (1975) and others, who, after extensive tests on wild-life toxicity reported that no deleterious effects were seen on birds and aquatic fauna from 4 fl. oz/acre (280 gm/ha).

Our results tend to confirm this opinion, except in the case of aquatic insects that depend on captured air film for breathing, e.g. notonectids and corixids, and for adult insects e.g. dragonflies, flying at the time of application. The mortality of the last named nontarget insect is unavoidable with an adulticide, but the effect of over-targetting is minimized

| TESTS | MANUFAC FORMUL. | % A.I. | A.I. lb/gl | A.I. kg/l. | MIX FOR 100 UNITS: INSECTICIDE | MIX FOR 100 UNITS: ADDITIVE | MIX FOR 100 UNITS: CARRIER | DELIVERY: Tot.sol. ml/ha | DELIVERY: A.I. gm/ha | EVALUATION: EFFECTIVEN'S[4] vs. MOSQUIT | EVALUATION: EFFECTIVEN'S[4] vs. SANDFL'S | EVALUATION: NON-TARGET Aq.[2] Ins- | EVALUATION: NON-TARGET Jelly Fish | EVALUATION: NON-TARGET Min-nows | EVALUATION: NON-TARGET Crabs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | SUMITHION CONC. | 93 | 10·1 | 1·21 | 30 S. CONC. | 40 H. A. N. | 30 DIESEL | 365·5 | 133 | INSUFF. | | high | nil | nil | nil |
| IV | SUMITHION 8 E | 77·7[1] | 8 | 0·95 | 9·9 S. 8E | — | 90·1 WATER | 731 | 69·6 | MARGIN. | | med. | | | nil |
| III | " | " | " | " | 15·3 | — | 84·7 | " | 107 | INSUFF. | | | | | |
| II | " | " | " | " | 20·3 | — | 79·7 | " | 142 | GOOD | | high | | negl. | nil |
| V | " | " | " | " | 20·6 | — | 79·4 | " | 144·5 | | MARGIN. | | | | |
| VI | " | " | " | " | 10·3 | — | 89·7 | 1463 | " | | " | | | | |
| VII | " | " | " | " | 27·4 | — | 72·6 | 731 | 191·5[3] | | GOOD | high | nil | v. low | |

TABLE II. Airsprays with SUMITHION, summary of formulations, dosages, effect on mosquitoes, sandflies and non-target animals.

1) Note, some formulations of SUMITHION'E' are 81% or 8·5 lb./gl..

2) Aq. insects exposed = Notonectids & Corixids i.e. captured air film breathers.

3) 191·5 gm./ha. A.I. = 2 fl.oz./ac. A.I., up to 4 fl.oz./ac. reported environmentally safe.

4) With HIGH DENSITY BITING FLIES control levels are:

| | |
|---|---|
| INSUFFICIENT | less than 93 % |
| MARGINAL | 94–96 % |
| GOOD | over 97 % reduction |

NOTE TO EMULSIFY SUMITHION CONCENTRATE ADD 10% v.v. TRITON X 193 & 5% TRITON X 180.

by spraying only after sundown when the target species is most active and most non-target species resting.

In conclusion we recommend Sumithion at 142 gm/ha A.I. delivered in aqueous solutions at 731 ml/ha for the control of *Ae. taeniorhynchus;* even if applied through dense mangrove canopy under tropical conditions.

## ACKNOWLEDGMENTS

We are indebted to Sumitomo Chemical America Inc., and Stauffer Chemical Co. for supporting this study with generous supplies of Sumithion® (Fenitrothion) insecticide.

We wish to thank the staff of the M.R.C.U., in particular Mr. J. F. Lesieur, the pilot, and Mrs. J. Giglioli for editorial assistance.

### *References Cited*

Himel, C. M. & Uk S. 1975. The biological optimum spray droplet size. Proc. Vth Int. Agri. Aviat. Congr. (England):234–242.

Nigam, P. C. 1975. Chemical Insecticides. p. 9–24 *in* Prebble, M. L. Aerial Control of Forest Insects in Canada. Information Canada, Ottawa K1A 0S9.

# GENERATION AND INSTAR SUCCESSION OF THE BLACK FLY *SIMULIUM PENOBSCOTENSIS* (DIPTERA: SIMULIIDAE)[1]

J. GRANETT[2]

Department of Entomology, University of Maine, Orono 04469

ABSTRACT. There were 3 generations of *Simulium penobscotensis* Snoddy and Bauer in 1978. The 2nd and 3rd generations were made up of 3 and 4 cohorts respectively. Development from instars 1–3 through the pupal stage took 9–13 days. Late August and September cohorts were numerically small.

## INTRODUCTION

The problem of black fly pests of humans during the summer has been prevalent in central Maine for more than a decade (Waters 1969, Sleeper 1975). The specific pest was originally thought to be *Simulium nyssa* Stone and Snoddy (Stone and Snoddy 1969). However, it was recently identified as a closely related species, *S. penobscotensis* Snoddy and Bauer, which has been indistinguishable from *S. nyssa* as an adult (Snoddy and Bauer 1978, May et al. 1977). Electrophoretic work with iso-enzymes indicated that *S. nyssa* either was not a biting pest or only contributed slightly to the problem. *S. penobscotensis* is primarily a warm river insect and uses vegetation as its larval and pupal substrate (Bauer 1977, Boobar and Granett 1978).

Determinations of instar frequencies in periodically sampled black fly populations have been used to establish number of generations and larval developmental

[1] Project supported by funds granted from the USDA under CSRS agreement No. 616-15-94 and ME 08038 (NE-118), and the Maine towns of Bradford, Brownville, East Millinocket, Enfield, Lincoln, Millinocket, Milo, Old Town, Orono, and Maine counties of Penobscot and Piscataquis, and the State of Maine.

[2] Present address: Department of Entomology, University of California, Davis, CA 95616.