OPERATIONAL AND SCIENTIFIC NOTES

DOSE-TIME RESPONSE BETWEEN *SIMULIUM VITTATUM* (DIPTERA:SIMULIIDAE) LARVAE AND ABATE 200E (TEMEPHOS)[1]

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Laboratory baseline data on the concentration-(dose)-time response relationship between insecticide treatments and target organisms in lotic waters (e.g., simuliid larvae) fulfill an essential first step in formulating field treatment requirements to achieve effective larval control. Optimizing these requirements is necessary because a portion or all of a toxicant is likely to be retarded as it encounters varying physical conditions while moving downstream. As a result, the interval of an exposure period at a given downstream point is usually increased from the initial time interval during which the toxicant was introduced.

When simulated for experimental purposes, this phenomenon was found to modify the effectiveness of spore suspensions of *Bacillus thuringiensis israelensis* used to control larvae of *Simulium vittatum* Zetterstedt (Frommer et al. 1980). In this study, the absolute quantity of inoculum required for satisfactory control decreased when the time interval of exposure was increased from 15 to 60 min. Studies by Muirhead-Thomson (1977, 1978) on the tolerance levels of several simuliid species to various concentrations of Abate® 20% EC have also suggested that mortality could possibly be influenced by the length of the treatment exposure time. Likewise, Jamnback and Means (1966), using methoxychlor against several black fly species, showed that there was not a direct correspondence between the change in concentration and time necessary to achieve comparable mortality at extended exposure periods (i.e., 6 to 12 hr).

Since the dose-time response phenomenon has clearly been demonstrated to exist using microbial insecticide suspensions, but only tentatively so using conventional insecticide solutions, this study was undertaken to provide preliminary data which might confirm this effect for Abate 200E[2] (temephos) and be useful for planning more elaborate field studies.

Late instar (5–7th) *S. vittatum* larvae were reared at 25°C from eggs collected from several streams at Holston Army Ammunition Plant, Kingsport, Tennessee. The 2 bioassay apparatuses used are nearly identical to those described by Hembree et al. (1980) except disposable wooden tongue depressors were substituted for the 120 ml plastic bottles that provided mixing and aeration.

Twenty (10/apparatus) 16 oz (480 ml) waxed paper cups were each filled with 180 ml of aerated well water. Ten larvae were placed into each cup, and the cups were positioned on the 2 bioassay apparatuses. The apparatuses were turned on and adjusted to operate at 120 rpm. Following this procedure, 0.5 ml of food (Tetramin®) was added to each test container to achieve a 0.5 mg/l concentration. After a 3 hr acclimatization period, the desired quantities of Abate (premixed in 20 ml of distilled water) were added to each test cup, bringing the total volume to 200 ml per cup. Nine different concentrations, plus one control, were used for the duration of each exposure. Six replications of each treatment concentration were conducted at 15 min, 30 min, 60 min, 90 min, 120 min and 24 hr exposures.

Once the exposure time was completed, the treatment solutions and larvae were poured off through a mesh screen, using a different screen for each concentration. Screens and larvae were rinsed thoroughly with tap water to remove residual Abate. Larvae were removed from the screens by using gentle air pressure and then placed in fresh cups containing aerated well water and 0.5 mg/l of food. These cups were repositioned on the apparatuses which contained new uncontaminated tongue depressors. Mortality counts were assessed after ca. 24 hr. Data were recorded as the number of dead larvae per 10 exposed. The statistical method utilized in analyzing these data was probit analysis as described by Barr et al. (1976).

The LC_{50} values for Abate 200E presented in Table 1 indicate that less total toxicant was required to provide the same level of mortality when exposure time was increased. Since all tests were conducted in a fixed volume in which the toxicant was thoroughly mixed, meaningful estimates can be made for the

Table 1. The mortality of 5th and 7th instar *Simulium vittatum* larvae to varying concentrations of Abate 200E at 6 exposure times.

Exposure times	LC 50 (ppm ± FL[1])	LC 90 (ppm ± FL[1])
15 min	0.322 (0.225–0.368)	1.608 (1.058–3.012)
30 min	0.237 (0.182–0.331)	1.937 (1.111–4.533)
60 min	0.094 (0.082–0.108)	0.269 (0.217–0.361)
90 min	0.049 (0.035–0.057)	0.168 (0.116–0.307)
120 min	0.051 (0.044–0.591)	0.191 (0.153–0.254)
24 hr	0.005 (0.003–0.008)	0.021 (0.017–0.033)

[1] 95% fiducial limits.

[1] The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of Defense. Use of proprietary names does not constitute endorsement.

[2] Experimental EC formulation (200 mg/l active ingredient) provided by American Cyanamid Company.

actual amount (total dose) that corresponds to the LC_{50} values. The effect of exposure time becomes more apparent when these estimates are compared. The LC_{50} values correspond to 0.0098 and 0.0102 mg of actual test material at the 90 and 120 min exposure times respectively. This is ca. one-half the amount required for a 60 min exposure (0.0188 mg) and ca. one-fifth and one-sixth the amount required for 30 and 15 min exposure periods respectively (0.047 and 0.064 mg). There is a difference of one order of magnitude between the amount required at 24 hr (0.001 mg) and that for the 90 and 120 min exposures.

A similar trend was apparent from LC_{90} values except for the 30 min exposure period. This value was greater than for the 15 min interval. This inconsistency may have been caused by sorption of the toxicant to the wax coating of test cups. This factor did not appear to be responsible for the other differences observed because if some temephos became bound, it would have tended to mask rather than enhance differences related to different exposure times. Thus, the differences observed in this study may have underestimated the true dose-time effect.

When LC_{90} values were used to estimate the total quantity of Abate 200E which must be applied during a given treatment duration (i.e., concentration × time), the 60 and 90 min intervals were lowest. They yielded estimates that were ca. 35% lower than the value for a 15 min exposure.

The similarity of the observed differences to those observed in some other studies (Frommer et al. 1980, Muirhead-Thomson 1977) also tend to support the interpretation that exposure time may be an important factor influencing the toxicity of Abate 200E. Thus, more thorough investigations utilizing flow-through and field tests appear to be warranted.

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POTENTIAL OF A TEMPERATE ZONE *TOXORHYNCHITES* FOR THE BIOLOGICAL CONTROL OF TROPICAL CONTAINER-BREEDING MOSQUITOES[1]

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For seventy years now, entomologists have considered using predaceous *Toxorhynchites* Theobald larvae for the biological control of container-breeding, vector mosquitoes (Steffan 1975). Those advocating their potential usefulness have stressed the following aspects of their biology (National Academy of Sciences 1973). First, the adults are non-blood sucking; second, all four larval instars are predaceous and the larvae are voracious; third, prior to pupation the larva often kills, but does not consume, all other inhabitants of its container; and fourth, females can seek out and oviposit in habitats that cannot be reached for conventional chemical control.

Attempts to use *Toxorhynchites* in classical biological control programs have not been successful for several reasons (Steffan 1975). Introductions of this mosquito onto islands where it formerly did not occur have not always resulted in its successful establishment. Where releases have resulted in establishment, the predator was not effective in keeping vector populations below the disease-transmission threshold. This is because, although the predator population exhibits a numerical response to increases in prey density, the temporal delay of this response always permits prey populations to increase to a large, and usually unacceptable size before their numbers are reduced by predation (Trpis 1973).

The potential usefulness of *Toxorhynchites* as a biological control agent is therefore likely to be confined to inundative release programs. Using *Toxorhynchites* in this way would involve the release of large numbers of gravid females prior to or during the preadult development of vector mosquito populations. The released females would then disperse and oviposit in the developmental sites of vector mosquitoes. However, *Toxorhynchites* larvae have a relatively long development time compared to that of vector larvae; and vector outbreaks are often difficult to forecast. These two factors could make inundative releases of *Toxorhynchites* ineffectual because, if outbreaks could not be predicted more than 2½ to 3 weeks in advance, there would not be sufficient time for the completion of *Toxorhynchites* prerelease development.

The biological characteristics of one of the three temperate species of *Toxorhynchites* could be exploited to facilitate the timing of inundative releases. *Toxorhynchites rutilus septentrionalis* (Dyar and Knab) occurs between 30 and 40 degrees north latitude in eastern North America (Trimble and Smith 1975).

[1] Presented at the joint annual meeting of the California Mosquito and Vector Control Association and the American Mosquito Control Association at the Capital Plaza Holiday Inn, Sacramento, California on 21 April 1982.