Preliminary field study on larvicide formulations for onchocerciasis vector control in Guatemala\(^1\)

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Abstract: Preliminary field study on larvicide formulations for onchocerciasis vector control in Guatemala was carried out in two rivers, Lavederos and Pajal, both located in San Vicente Pacaya, Department of Escuintlá, in 1978. Temephos was more effective than fenitrothion against the larvae of Simulium ochraceum at the dose of 1 ppm (AI) for 10 min water discharge. Using temephos, no marked difference was observed in efficacy among the three formulations, namely 50% EC, 50% WDP and 10% solid. A solid formulation of temephos was considered to be the most convenient in field operation for its easiness in transportation, usage and safety in handling. Within two weeks after application, no mature larvae and pupa appeared in controlling area. A fortnightly application interval was selected, based on this result.

Introduction

The main purpose of the present study was to determine the strategy of forthcoming onchocerciasis vector control operation in Guatemala, in the context of larvicide formulation and its efficient usage.

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The prevailing worldwide method of black-fly larvae control is to apply a definite dose of insecticide for a definite time to the breeding streams (Ogata et al., 1956; Orii et al., 1964; Swaby and Schenk, 1967; Wallace et al., 1973; Muirhead-Thomson, 1977). In the onchocerciasis control scheme in West Africa, temephos EC is being applied to the rivers directly by aircraft with considerable success (Davies et al., 1978). The fact that onchocerciasis vectors in that part of the world breed in large rivers with enormous volumes of running water justifies such an aircraft operation.

The situation in Guatemala is entirely different. Simulium ochraceum, the principal vector of onchocerciasis, breeds in numerous small tributaries, with a water discharge of only 0.1–1.0 liter/second, which are distrib-
Fig. 1 Numbers of blackfly larvae from natural substrates during 5 min collections, before and after insecticide application with 1 ppm/10 min in the Los Lavaderos River

The solid line represents treated sites and the broken one untreated sites (upstream).
Fig. 2 Number of blackfly larvae observed on five artificial substrates before and after insecticide application in the Los Lavaderos River. The solid line, treated; broken line, untreated.
uted extremely upstream and usually covered by dense forests (Lea and Dalmat, 1955). The only feasible vector control method under such conditions is to trace all breeding streams and apply insecticide from the ground.

It should be pointed out here that most blackfly control trials reported to the present, either for onchocerciasis vector control or for nuisance control, deal with blackfly species breeding in streams with much higher discharge. It is well known that the smaller the river, the higher the dose of insecticide needed. Therefore, efficient dose of any insecticide, together with its adequate formulation should be studied under Guatemalan conditions, in order to establish vector control strategy in Guatemala. The Guatemalan vector control operation in the Lavaderos River Basin (Nakamura et al., 1981) and Barretal and Zapote River Basin (Takaoka et al., 1981) was initiated in 1979 and based on information of the larvicide presented herein.

Study area

The studies were carried out in two rivers, Lavaderos and Pajal, both located in San Vicente Pacaya, Department of EscuintlÁ, Guatemala. In the Lavaderos River Valley, there are many tributaries harbouring mainly S. ochraceum larvae. Ten tributaries were selected for the first trial and three for the second. The Pajal River has two long tributaries harbouring S. ochraceum, S. metallicum, and S. callidum.

The discharge of running water from the tributaries under trial for the months of July to October 1978, varied from 0.1 to 1.0 liter/sec, while water temperature ranged from 18°C to 22°C.

Materials and Methods

The effectiveness of two insecticides, temephos and fenitrothion, each using three formulations, i.e., 50% emulsifiable concentrates (EC), 50% water dispersible powder (WDP), and 10% slow release solid formu-
lation, were compared to determine the most suitable formulation for future operations. The solid 40 g brick formulation was produced by mixing 11 parts temephos (88%), 30 parts polyvinyl alcohol, 50 parts fat powder and 9 parts detergent (Bannox PW) by weight.

All the larvicides were applied at the dose of 1 ppm (AI) for 10 min water discharge. The EC and WDP formulations were diluted in the watering pot with approximately 5 liters of stream water, then poured into the stream during 10 min. The solid formulations enclosed in a wire net were placed on the riverbed.

The effectiveness was evaluated by comparing larval density before and after the larvicide application, using two methods: number of larvae attached to artificial substrates, silicone tubes (Nakamura et al., 1978) and number of larvae collected from natural substrates during 5 min. Five artificial substrates have been placed 7–10 days prior to the larvicide application for colonization.

The larvae were identified and classified into 4 categories, (1) mature larvae (with pupal filaments), (2) large larvae (>3.5 mm), (3) medium larvae (2–3.5 mm) and (4) young larvae (<2 mm), according to the body length measured microscopically.

In the preliminary tests, observation sites were registered 5 to 10 m upstream (for untreated control) and 30 to 60 m downstream from the application points. And tests were duplicated on all formulations of temephos and fenitrothion WDP. In the effective range tests, observation sites were extended

Fig. 4 Stage spectrum of immature blackflies on five artificial substrates before and after application of 1 ppm/10 min of temephos solid in a tributary of the Pajal River

p (pupa), a (mature), b (>3.5 mm), c (2–3.5 mm) and d (<2 mm).

These legends are common with Figs. 5, 6 and Table 1.
370 m downstream.

The observations were repeated at each site, immediately before the application and on days 1, 3 (or 4), 6 (or 7), 14, and 21.

In order to obtain information on duration from the insecticide application to the larval detachment, polyethylene films, 20 cm × 30 cm, were submerged in the streams 7 days prior to application. Larval detachment was observed directly from the films.

Results

Preliminary tests

The results of the preliminary tests are shown in Fig. 1 on artificial substrates and in Fig. 2 on natural substrates.

In the application of any formulation of temephos, no larvae were observed on day 1 or day 3. However, in the application of fenitrothion, there remained a few larvae even on day 1. Thus, this clearly demonstrates that temephos is more effective than fenitrothion under the present conditions. Among the three formulations of temephos, no marked difference in effectiveness has yet been observed.

Effective range tests

The results are shown in Fig. 3. In the application of temephos solids, with the dose of 1 ppm for 10 min discharge, all larvae were flushed away at least 160 m downstream from the application site.

Reappearance of immatures after the applications

As shown in Figs. 1, 2, and 3, no larvae...
were observed until day 3 (or day 4), with the application of any formulation of temephos.

The stage spectrums of immature blackflies before and after the application are shown in Fig. 4 (temephos, on artificial substrates), Fig. 5 (temephos, on natural substrates), and Fig. 6 (fenitrothion, on natural substrates).

In the application of temephos solids, no larvae were observed either on day 1 or day 4 in the treated sites. Young larvae (d in Figs. 4, 5 and 6) first reappeared on day 7. On day 14, young (d), medium (c) and large (b) larvae reappeared, but neither pupae, nor mature larvae (a) were found. Pupae reappeared on day 21. No marked difference in the reappearance pattern was observed among the four observation sites, which were distributed 30 m to 160 m downstream from the application site.

In the application of fenitrothion solids, even on day 1, a few larvae (b, c, d) remained at the site 150 m downstream. A few mature larvae (a) were found on day 7, and a few pupae on day 14. In this test, however, it was unfortunate that before the application neither pupae nor any stage of larvae were found at the untreated site (upstream) or at two of the to-be-treated sites, 25 m and 72 m downstreams.

Nevertheless, it is clear from the above results that temephos is more effective than fenitrothion.

Drifting of larvae by the application

Ten days before larvicide application, polyethylene films (20 cm x 30 cm) were placed on the rocks in the riverbed, as artificial substrates. Two formulations of temephos were applied 30 m upstream from the films. The number of larvae on each film was
Table 1 Reduction of immature blackfly after insecticide application, observed on artificial substrate in the Los Lavaderos River

<table>
<thead>
<tr>
<th>Larvicide</th>
<th>Stage</th>
<th>Before</th>
<th>Numbers of immature observed</th>
<th>After (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Temephos</td>
<td>a</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WDP</td>
<td>b</td>
<td>22</td>
<td>36</td>
<td>40</td>
</tr>
<tr>
<td>1 ppm/10 min</td>
<td>c</td>
<td>16</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Temephos</td>
<td>a</td>
<td>13</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>solid</td>
<td>b</td>
<td>13</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>1 ppm/10 min</td>
<td>c</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>d</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Temephos</td>
<td>a</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>solid</td>
<td>b</td>
<td>13</td>
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<td>1 ppm/10 min</td>
<td>c</td>
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<td>3</td>
<td>3</td>
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<tr>
<td></td>
<td>d</td>
<td>0</td>
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</tr>
</tbody>
</table>

counted 180 min after the insecticide application. The results are shown in Table 1.

After 30 min, larvae began to detach from the film and drift, although even after 180 min, a few still remained. The times for drifting away in using the two temephos formulations were almost equal.

**DISCUSSION**

It was revealed that temephos was more effective than fenitrothion against the larvae of *S. ochracerum*, when it was applied at the dose of 1 ppm/10 min of water discharge in the small tributaries under study. Using temephos, no marked difference was observed in the efficacy among the three formulations namely, EC, WDP and solid. All larvae were flushed away at least 160 m downstream from the application site at the dose of 1 ppm of temephos solid. This dose of temephos is considered excessive compared with that used in the Volta River Basin (0.05 ppm/10 min, Davies *et al.*, 1978) and in Canada (0.15 ppm/30 min, Swabey and Schenk, 1967; 0.075–0.1 ppm/15 min, Wallence *et al.*, 1973).

From the results of this study, the downstream effectiveness of the insecticide was much shorter than that of the VRB, which eliminated larvae for 32 km downstream (Davies *et al.*, 1978). Though the reason is not fully clarified, there are some possibilities to support these results.

First of all, the breeding site of *S. ochracerum* is limited to the area near the source of river with small water volume and many falls, rapids and pools. Therefore, the river basin harbouring *S. ochracerum* is very short. Insecticides could be absorbed by vegetation and soil, or trapped in pools. Furthermore, the insecticide application of 1 ppm/10 min seems exaggerated. The amount of insecticide required for the practical control operation is very little, since the volume of water at the application site is small. Therefore, expenditure of insecticide for control operation is not a major importance. Two weeks or more after the application of temephos, with dosage of 1 ppm/10 min, the mature larvae or pupae of *S. ochracerum* reappear in the river. A fortnightly application interval was selected, based on this result. This is very important data to orientate the con-
control strategy in the field. The interval in the VRB is weekly, since the reappearance of larvae is about 8 days (Davies et al., 1978). Although no marked differences were observed among temephos formulations, the ideal formulation for the practical control requires more studies in various types of rivers with different vegetation, flow velocity, water volume and riverbeds. These conditions have strong influence on the efficacy of insecticides. A solid formulation is considered to be the most convenient in field operation for its easiness in transportation, usage and safety in handling.

The authors could establish a strategy for the control operation of the larvae of S. ochraceum, the vector of Guatemalan onchocerciasis, based on the conclusion that the fortnightly application of 1 ppm/10 min of temephos had a potentiality for the control of the larvae of this insect.

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