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USE OF TEMEPHOS LARVICIDE IN SOLID FORM FOR THE CONTROL OF ONCHOCERCIASIS IN GUATEMALA[1,2]

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The work reported here was performed as part of a coordinated onchocerciasis control program in Guatemala. Its aim was to find an appropriate way of making and applying a solid formulation of larvicide for use against larvae of the main vector species, Simulium ochraceum, *which are found exclusively in fast-moving mountain streams of the endemic zone.*

Introduction

Three onchocerciasis vectors are recognized in Guatemala: *Simulium ochraceum, Simulium metallicum,* and *Simulium callidum (1);* but the most important species is *S. ochraceum.* Its larvae generally breed in streams that carry a small volume of water and run under a canopy of dense vegetation, but that move swiftly because of the steep slopes of the foothills through which they fall. The larvae occur along finite stretches of these watercourses, never throughout their length *(2, 3).* Large numbers of such larval habitats are scattered about the area endemic for onchocerciasis.

Large-scale application of larvicides is extremely difficult under these circumstances, it being very hard to transport and apply appropriate materials. The rugged terrain precludes the use of motor vehicles, which are employed in Africa to combat *S. damnosum (4).* And since the elimination of simuliid larvae is a protracted process, it is imperative to find an effective application method that will also make it possible to reduce the number of treatment sites and so save time and effort—particularly if the operation must cover the country's entire endemic area.

A larvicide appropriate for this purpose should come in the form of solid pieces that are easily transported and will dissolve in a stream of water within 10 or 20 minutes. Such a product would reduce the effort required and would accelerate the application process, so that a larger area could be covered in a single day. We therefore performed a series of trials in August-December 1979 in order to develop an appropriate solid formulation of the larvicide temephos and to test the effects of that formulation on simuliid larvae in Guatemalan streams.

Materials, Methods, and Results

Production of a Solid Temephos Formulation

We began with three commercial forms of temephos (recognized as the larvicide most effective against simuliids in Guatemala), these being a 5 per cent emulsion, 3 per cent granules, and a 5 per cent wettable powder. To these we added a surface-active agent, polyvinyl alcohol, animal fat, and in one case liquid soap. All of these ingredients were found to be available in the country.

Table 1 shows the proportions of the chemicals used in a representative group of the 61 formulations tested, the extent to which the

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Table 1. The relative amounts of ingredients used in the various temephos formulations tested, showing the degree to which these formulations solidified and the time that each needed to dissolve.

Formulation No.	Proportions of chemicals utilized (%)[a]							Degree of solidification	Dissolution time
	EM	GR	PH	SAA	PA	AF	W		
1-10	+[b]			+	+	+		did not solidify	
36		57		11	3	29		did not solidify	
14		29			29	29	13	very hard	did not dissolve
61		33		25	17	17	8	very hard	did not dissolve
20			12	31	19	19	19	paste-like	did not dissolve
30			50	10	5	5	30	solid	2 hours
32			55	11	3	3	28	friable	10 minutes
44			62	31	1		6	slightly gummy	25 minutes
45			65	16			19	slightly friable	10-15 minutes
49			70	15[c]			15	solid	did not dissolve

[a]EM = 5 per cent temephos emulsion; GR = 3 per cent temephos granules; PH = 5 per cent temephos wettable powder; SAA = surfactant; PA = polyvinyl alcohol; AF = animal fat; and W = water.
[b]+ = various proportions.
[c]Liquid soap.

various mixtures solidified, and (for those that solidified) the dissolution time in water. The time of dissolution was found by the following method: A tablet of insecticide was inserted into a small metal screen cage and placed in an artificial stream of running water; a record was then made of the time it took the tablet to dissolve.

None of the formulations using the temephos emulsion solidified satisfactorily, despite numerous trials and use of many different proportions of the other ingredients. One formulation using temephos granules (formulation number 36) did not solidify; formulations 14 and 61 reached the desired solid state, but the resulting tablets failed to dissolve in two hours.

All six of the test formulations using the wettable powder solidified to some degree. Formulation 20 had a paste-like consistency and failed to dissolve in two hours; formulation 30 solidified and dissolved in two hours; formulation 32, containing smaller amounts of polyvinyl alcohol and fat, dissolved in 10 minutes but showed a tendency to crumble. Formulation 45, which used only the surface-active agent and water (no polyvinyl alcohol or fat) was less friable and dissolved in the stream of water in only 10 to 15 minutes. Formulation 49, which included liquid soap, solidified well but failed to dissolve in two hours.

Of the solid formulations tested in the laboratory, formulation 45 showed both effective solidity and appropriate solubility. Specifically, it dissolved in running water in 10 to 15 minutes but did not crumble during transportation from the laboratory to the point of application. This formulation was produced as follows: 20 grams of temephos wettable powder were mixed with 4.9 ml of surface-active agent and 5.8 ml of water. The resulting paste-like mass was placed in a shallow, rectangular wooden mold until it solidified; it was then ready for application.

Field Trials

Table 2 shows the results obtained with field trials of formulation 45 applied to streams at two farms named Medio Monte and Nimaya (see Figure 1). In all cases but one a dose of solid larvicide amounting to 1.0 parts of temephos per million parts of water was placed in a wire-mesh cage, and the cage was placed in the water for 10 minutes. The level of toxicity for the simuliid larvae was assessed by counting the number of larvae collected over a ten-

Table 2. Results of field trials with formulation 45. Except in stream "E," all the treated streams received 1 part per million of temephos for 10 minutes.

Sites and streams (designated A-G)		Volume of water per second (liters)	Water temperature (°C)	No. of larvae collected before application/No. of larvae collected 2 hours after application at the indicated distances (in meters) from the point of application: 10	30	50	70	100	150	200	*Simulium* species collected
Medio Monte	A	0.5	20.5	3/0	28/0		73/18[a]				*S. metallicum, S. horacioi*
	B	2.2	20.5	45/0	20/0		61/4[a]				*S. ochraceum, S. callidum, S. metallicum, S. horacioi*
	C	7.3	21.0	51/0		30/0		24/4[a]			*S. ochraceum, S. callidum, S. metallicum, S. rubicundulum*
	D	5.8	21.0	84/0		89/0		84/0			*S. ochraceum, S. callidum, S. metallicum, S. horacioi*
	E[b]	0.08	21.5	12/0		56/12[a]		41/62			*S. ochraceum, S. callidum, S. metallicum*
Nimaya	F	12.0	23.0			50/0		4/0	121/1[a]	30/3[a]	*S. metallicum, S. callidum*
	G	8.3	23.0			50/0		64/0	59/1[a]	21/1[a]	*S. ochraceum, S. callidum, S. metallicum*

[a]Moribund larvae.
[b]Dosage: 0.5 parts per million of temephos for 10 minutes.

minute period just before and two hours after the application (see Table 2).

In the Medio Monte streams, the larvicide's impact was measured at distances up to 100 meters from the point of application. Where the water-flow in the stream was between 0.5 and 7.3 liters per second (see Table 2), and where a concentration of one part per million (ppm) was used, no larvae could be found 10 to 50 meters downstream two hours later. A few dying specimens were found between 70 and 100 meters away. These results indicate that a dosage of 1.0 ppm for 10 minutes was effective up to 100 meters away.

Figure 1. Onchocerciasis foci in Guatemala and the locales where the field trials of temephos formulation 45 were performed.

In the Nimaya streams, the larvicide's impact was tested up to 200 meters downstream at the same dosage, but in larger water flows than those found in the Medio Monte streams. No larvae were found two hours after the application at points 50 and 100 meters from the application site, and only a few moribund specimens were found at places 150 and 200 meters away. (The Second Report of the Onchocerciasis Control Project in Guatemala *(3)* reported on the toxicity of a solid temephos formulation that killed a majority of exposed simuliid larvae within an hour and left other larvae observed at that time in a moribund state. The moribund larvae died within three hours. In the trials being reported here it was also assumed that moribund specimens subsequently died.)

Formulation 45 was also applied at a concentration of 0.5 ppm to a Medio Monte stream with a relatively small water-flow rate of 0.08 liters per second. Two hours later, no larvae were found 10 meters downstream, but some moribund specimens were found 50 meters downstream and many live ones were found 100 meters away. This indicates that the ten-minute 0.5 ppm dosage was effective only at distances up to 50 meters away from the application site; but it should be noted that there are many tributary streams less than 50 meters long where that dosage could be used.

Discussion and Conclusions

Given the topography of the rivers that harbor the simuliid vectors of onchocerciasis in Guatemala, a solid larvicide offers numerous advantages. Chief among these is that placing a metal screen cage containing the correct amount of solid larvicide in a stream takes very little time and much less effort than is required to apply liquid larvicide—because the liquid has to be added slowly to the running water for 10 consecutive minutes. For this reason, a pair of workers who had been able to make only 25 liquid larvicide applications in one day were able in the same time to make more than 75 solid larvicide applications. The solid form is also light and easy to transport, and no additional receptacle need be taken along to make up the suspension. An added fringe benefit is that the mesh containers used to hold the larvicide tablets provide an easy way for supervisors to confirm that the larvicide has indeed been applied.

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SUMMARY

The larvae of *Simulium ochraceum,* the principal vector of onchocerciasis in Guatemala, inhabit small mountain streams. A trial of solid insecticide (temephos) formulations applied to control these larvae was made in August-December 1979. The most appropriate of various formulations produced in the laboratory was a solid mixture of 5 per cent temephos wettable powder (65 per cent), surface-active agent (16 per cent), and water (19 per cent). This mixture was sufficiently solid for transportation purposes and would dissolve reasonably fast (in 10 to 15 minutes) in running water.

Field tests of this formulation's effectiveness against *S. ochraceum* larvae were performed at a number of streams in the endemic area. Applied so as to administer a dose of one part per million of temephos for 10 minutes, the formulation was found to control *S. ochraceum* larvae up to a distance of 200 meters from the point of application.

This larvicide was produced locally with readily available ingredients; it proved easy to make; and its production involved no complex procedures. The results of the field tests demonstrated that it was easy to apply, that it was more convenient to use than liquid formulations, and that it could be used effectively to combat the main vector of onchocerciasis in Guatemala.

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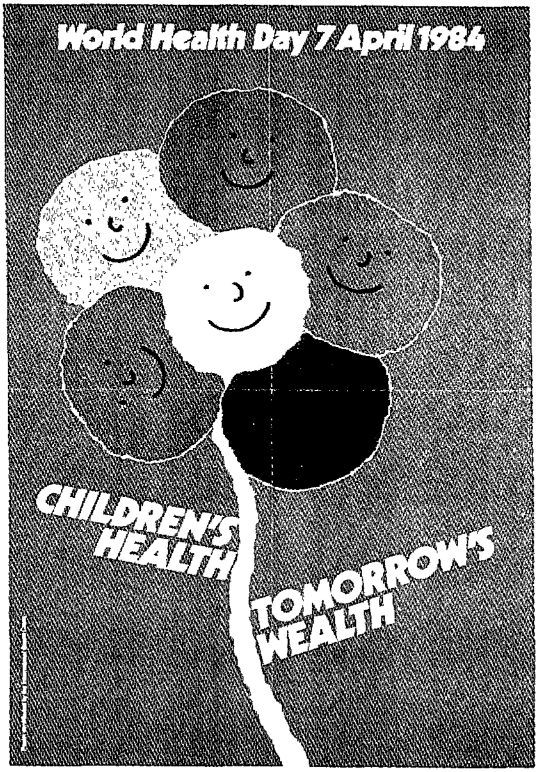
WORLD HEALTH DAY—7 APRIL 1984—CELEBRATED AT THE PAN AMERICAN HEALTH ORGANIZATION



CHILDREN'S HEALTH/TOMORROW'S WEALTH

Detailed information on this World Health Day theme will be presented in the *Bulletin's* next issue (vol. 18, no. 2, 1984).