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PRELIMINARY TESTS ON THE USE OF TEMEPHOS FOR THE CONTROL OF BLACK FLIES (DIPTERA: SIMULIIDAE) IN NORTHERN QUEBEC

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ABSTRACT. Preliminary tests have been conducted in northern and southern Quebec on the use of temephos for the control of the larvae of *Simulium venustum* Say, the main man biter in those regions. The larvae are usually concentrated in the first 30 m of streams below lake outlets and control has to be done when the water temperature is around 8°C or 10°C. Our tests at 0.3, 1 and 3 ppm for 20 min with the emulsifiable concentrate of temephos in ground application show that efficiency of the larvicide immediately below site of application could be closely related to water temperature. At 8°C to 10°C percentage of larvae detaching from artificial substrates was lower than 20%.

INTRODUCTION

The recent development of northern Quebec has raised a problem to which urban populations of the south had not yet been exposed: biting flies, and especially black flies. Operational control of black flies being considered desirable for workers and their families, a study program was set up in 1976 for the village of Radisson to find: 1) where and when black fly larvae were breeding, 2) by which means breeding sites of biting species could be controlled, in a 10 to 15 kilometers radius around. The survey done in 1976 gave the answer to the first question. It turned out, as expected, that *Simulium venustum* Say was the main pest. Mature larvae were to be found by the end of May, when the water temperature had reached 8°C. The main breeding sites were medium to large streams, and high densities of larvae were usually restricted to the first 30 meters below lake outlets and beaver dams, as was already observed in southern Quebec (Back and Harper 1979). The next step was taken in 1977, when we tried to control typical breeding sites with a larvicide.

METHODS

In the vicinity of Radisson (53°45′ N, 77°30′W) four streams were chosen from a map of potential breeding sites of black fly larvae drawn by the G.R.I.P.[1] in 1976. The experiments were done between the 2nd and the 15th of June. Two additional streams were selected in the Trois-Rivières area (46°18′N,72°37′) and were treated between the 4th and the 30th of August.

As the experiment was a preparation for eventual large-scale controls of black fly larvae, we tested the only insecticide approved for this purpose in Canada, Abate® 4E (a 43% solution of temephos diluted with triton X-100) which was provided by Kem-San of Canada Ltd. Ground operations were considered the simplest way for the application of the insecticide. In order to have an immediate mixing of insecticide with water, we modified Fredeen's technique (1970) by using two portable pressure tanks connected together. The first tank is empty and its large air volume helps keep a constant 30 lbs/sq. in. pressure in the second tank, which contains the insecticide added with water to make up a constant initial volume. Level of the mixture is read by an external gage and it is possible to calibrate the nozzle to have the spraying done in any desired time. The pressure is strong enough to cover the entire width of the stream with a swath of insecticide 2 or 3 meters above the lake outlet or the beaver dam. Discharge of the streams, which determines the amount of insecticide to be used, was measured with a digital flowmeter.

Tested concentrations of temephos were 0.3 ppm (recommended), 1 ppm, and 3 ppm. Tables 1 and 2 give the location and date of treatments, discharge and water temperature of the streams, and the concentrations of Abate. Spraying time was 20 minutes.

The impact of the treatments was estimated by two methods, larval counts on artificial substrates and drift samples. The first method is widely used (Peterson and Wolfe 1958, Williams and Obeng 1962, Swabey and Schenk 1967, Jamnback 1969). White squares of corrugated fiberglass (150 cm^2) were placed in the streams a few days before treatments to allow for colonization by larvae. Pupae were not used in the counts because it is difficult to assess the survival of a pupa in a cocoon. For most experiments the impact of macroinvertebrates was studied with drift nets of the Hardy type (Hynes 1972), placed 20 to 25 meters downstream of spraying points. The small mouth (11 cm) and length (1m) of these nets avoid clogging and damage by water pressure.

In the experiments, the nets were placed in the streams for 24 hr and emptied just before treatments, as the larval counts were made. Counts were repeated and nets emptied again 24 hr later. The larval counts in tables 1 and 2 are the mean number of larvae found on three substrates placed at 5 to 25 meters downstream of point of spraying.

RESULTS

In Tables 1 and 2 detachment of larvae is assumed to be mortality, since almost all larvae were found dead in the drift nets when detachment percentage was high. The most abundant groups of insects in the drift were the Chironomidae, Ephemeroptera, Trichoptera and Diptera pupae.

Table 1 shows that for a same concentration (0.3 ppm) of insecticide detachment percentage is highly variable, ranging from 0% to 98% (#1 and 5). Drift results are also highly variable, but there is generally a corresponding increase when detachment is high (#4,5,6,8). For instance in treatment #6, where detachment was estimated at 65%, black fly drift increased 58 times and chironomid drift 21 times. Table 2 (treatments at 1 ppm and 3 ppm) show no evident increase in detachment or drift when compared to treatments at 0.3 ppm. Detachment ranges between 10% and 67% and there is a slight increase in drift only at treatments #10 and 12.

Table 1. Larval counts on substrates and drift results for treatments with 0.3 ppm Temephos for 20 minutes

Treatment #	1		2		3		4		5		6		7		8	
Station	A*		B*		C*		D		D		D		C		C	
Date	02/06		09/06		14/06		04/08		05/08		11/08		28/08		30/08	
Temperature	12°C		9°C		9°C		19°C		19°C		19°C		24°C		17°C	
Stream discharge	24 l/s		100 l/s		100 l/s		7.5 l/s		7.5 l/s		7.5 l/s		48 l/s		41.6 l/s	
DRIFT	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
Simuliidae	48	108	—	—	—	—	23	392	120	27831	21	1210	12	0	8	61
Chironomidae	12	21	—	—	—	—	867	222	0	406	184	3985	84	49	112	764
Trichoptera	0	1	—	—	—	—	0	0	0	0	73	301	0	0	0	0
Ephemeroptera	0	0	—	—	—	—	0	224	0	0	0	475	0	0	0	0
Diptera pupae	0	1	—	—	—	—	8	32	0	0	73	203	36	11	0	0
LARVAL COUNTS																
Pre-treatment	106		82		73		98		85		62		22		27	
Post-treatment	113		75		61		64		2		22		1		7	
% detachment	—		9		16		65		98		65		95		74	

* Treatment site in Radisson.

Table 2. Larval counts on substrates and drift results for treatments with 1 ppm and 3 ppm Temephos for 20 min.

Treatment #	9		10		11		12		13	
Station	A*		E*		C		F*		C	
Date	05/06		15/06		23/08		15/06		25/08	
Temperature	10°C		12,5°C		17°C		14,5°C		17°C	
Steam discharge	25 l/s		382 l/s		49 l/s		442 l/s		49 l/s	
Concentration of Abate	1 ppm		1 ppm		1 ppm		3 ppm		3 ppm	
DRIFT	pre	post	pre	post	pre	post	pre	post	pre	post
Simuliidae	48	37	48	1070	18	14	98	647	43	67
Chironomidae	—	—	472	290	147	33	240	92	10	149
Trichoptera	—	—	0	0	0	0	0	27	0	0
Ephemeroptera	—	—	0	70	0	0	0	15	0	1
Diptera pupae	—	—	0	0	110	17	48	5	11	20
LARVAL COUNTS										
Pre-treatment	124		10		110		22		27	
Post-treatment	112		9		58		17		9	
% detachment	10		10		47		23		67	

* Treatment site in Radisson.

Comparison of all factors with detachment percentages gave no results, except in the case of temperature. In Fig. 1 detachment is plotted against temperature and can be compared with the normal sigmoid curve and its 95% confidence interval, computed by probit analysis (Daum 1970). Comparison of data with the curve shows the possibility of temperature being a key factor in insecticide efficiency.

DISCUSSION

The experiment was devised to estimate the efficiency of temephos on black fly larvae and its impact on other insects. No strong clue on the impact can be deduced from the drift results because of their discrepancies. Reasons for this could be a too small amount of water filtered by the nets, intrinsic variations in the drift or the shortness of stream stretches sampled. In a similar type of experiment good drift results were obtained by Helson and West (1978), but with nets placed at the downstream end of treated streams.

As temephos concentrations and method of application could not account for the variations observed in detachment, other factors were considered. Dominant species in all streams were restricted to four species, i.e. *Simulium venustum, S. decorum, S. verecundum* and *S. tuberosum,* the latter two being more important in August. The size of larvae may influence their sensitivity to insecticides (Wallace et al. 1976), but in this experiment proportion of sizes was equivalent in all streams. So identity and larval sizes of treated species were discarded as causes for variation in detachment.

Comparison with the literature is arduous, since many factors are either different from our experiment (aircraft application instead of ground application, lab tests instead of field tests, other chemicals, . . .), or simply not mentioned (water temperature, distance between application point and observation points, . . .). One of the observations to be mentioned though, is the inefficiency in the first 150 m reported by Quélennec (1970) in Africa. Insecticide efficiency is related to the (time of exposure/concentration) ratio. Travis et al. (1967) have found that doubling time of exposure is more effective than doubling the concentration. As the length of an insecticide plug increases along its downstream course (Wallace et al. 1976), one may assume that efficiency

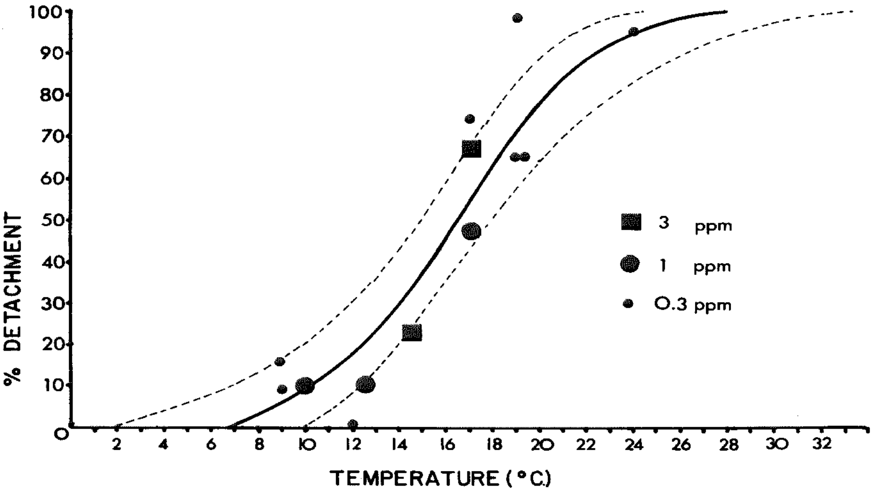

Fig. 1. Probit analysis of larval detachment results versus temperatures for treatments at 0.3, 1, and 3 ppm for 20 min.

of insecticide will increase for some distance downstream of treatment site. This could explain why in treatment #9 10% detachment was observed, under cold water conditions, whereas substrates placed 300 m below showed 100% detachment (data not included in the results). On the other hand our experiments at higher water temperatures gave good results immediately below point of application.

Finally formulation of temephos is also to be considered. Particulate formulation of temephos, as a wettable powder, has proven effective at 0.1 ppm for 15 min (Helson and West 1978), but in this case the temperature was presumably high and observations were made over 100 m downstream. In liquid formulation, the dilution of temephos in fuel oil or heavy aromatic naphtha (H.A.N.) was found more effective than use of the emulsifiable concentrate (Jamnback et al. 1968). In this case we have to consider the effects of 2 compounds because H.A.N. has its own insecticidal properties (Wallace et al. 1973). Up to 100% detachment has been obtained at 137 m downstream with a mixture of temephos and H.A.N. at 8°C (Wallace et al. 1973), but here again no observations were made immediately below treatment site.

Examination of Fig. 1 gives a clue for temperature being a key factor in insecticide efficiency, and our results indicate that 16.5°C would be the turning point, which is well over treatment conditions in northern Quebec. Temperature influence on toxicity has been underlined by some authors (Maire 1971, Matsuo 1970) but few studies, if any, have been made in this way. The mode of interaction between temperature and detachment of black fly larvae would have to be found if the hypothesis is true. It could be a physical or chemical mode, involving the mixing with water or breakdown of the insecticide, or a biological mode of involving susceptibility of the larvae to the insecticide.

It may be concluded that black fly control in northern Quebec has several implications: high efficiency immediately below point of application of the insecticide and at low temperatures (>10°C), and of course selectivity towards black fly larvae. The literature and our experiments do not give the answer to this problem at the present time. As demands for black fly controls will eventually increase in the near future, and considering that biological control is not yet available, we feel that research on insecticides for black fly control under northern conditions and their impact should be intensified.

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