PETROLEUM OIL AND NONANOIC ACID AS MOSQUITOCIDES AND OVIPOSITION REPELLENTS

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ABSTRACT. Nonanoic acid was tested under field conditions to determine its effect on mosquito larval and pupal mortality. Nonanoic acid was also applied in combination with a larvicidal petroleum oil to determine their joint action. Results showed that nonanoic acid was effective in reducing larval and pupal populations at concentrations as low as 20 ppm. In combination with the petroleum oil, nonanoic acid reduced the ovipositional activity of mosquitoes and decreased immature mosquito populations in the treated ponds.

INTRODUCTION

The ovipositional repellency of organic infusions to mosquitoes has previously been reported in the literature. Kramer and Mulla (1979) showed that a 1% lab chow infusion contained factors which were proven to be repellent to both *Culex quinquefasciatus* Say and *Cx. tarsalis* Coquillett. Hwang et al. (1980) isolated the bioactive principles in the infusion and identified them as lower aliphatic carboxylic acids. When tested in the laboratory, all of these acids showed ovipositional repellency to mosquitoes at relatively high concentrations (Kramer et al. 1980). Further research on the activity of higher aliphatic carboxylic acids from C_5 to C_{13} showed that C_9 acid, nonanoic acid, was the most active in repelling ovipositing mosquitoes (Hwang et al. 1982).

Nonanoic acid was then tested under field conditions to determine its effectiveness as an ovipositional repellent. Its application to water surface resulted in complete ovipositional repellency for 1 day at 25 ppm, 2 days at 50 ppm, about 5 days at 75 ppm, and 6 to 7 days at 150 ppm (Schultz et al. 1982). Although the application rates are much higher than those of conventional insecticides, it is still interesting to note and confirm the activity of these behavior-modifying chemicals.

Petroleum oils are frequently used as larvicides against mosquitoes. One of these, GB-1356 (Witco Chemical Corporation, Los Angeles, California), is effective against larvae and pupae of *Cx. tarsalis* when applied at 1–2 gal/acre (Mulla and Darwazeh 1981). In the present study, we proceeded to determine the joint action of nonanoic acid and GB-1356 (0.5 gal/acre) in providing effective mosquito control. Thereupon the larvicidal petroleum oil would kill the existing larvae and pupae, and nonanoic acid would prevent oviposition in the breeding sources. In addition, we intended to determine the effectiveness of nonanoic acid as a larvicide and pupicide when applied alone under field conditions.

METHODS AND MATERIALS

Three field tests were conducted during the summer of 1981 at the Aquatic and Vector Control Research Facility, University of California, Riverside. In each test, 12 rectangular ponds filled with fresh water from a reservoir were used. Water surface in the ponds measured 3.6 × 7.2 m, and the depth was 0.3 m. Twelve ponds were randomly placed into 4 groups with 1 group used as a check and the other 3 groups treated. The ponds were flooded 1 week prior to testing and sampled for egg rafts before and after treating with test formulation. Egg rafts were visually counted over entire ponds but not collected as egg rafts could easily be observed and counted in these ponds. Larval and pupal counts were also made by taking 5 dips per pond from predetermined locations around the perimeter of the ponds. Larval samples were concentrated and returned to the laboratory for counting and species determination. Data were transformed into log (N + 1) and analyzed for significant differences with the Duncan's multiple range test at the 0.05 level. Species determination was made only on larvae but not on eggs.

EXPERIMENT 1. One group of ponds was treated with GB-1356 at the rate of 0.5 gal/acre. Another group of ponds was treated with nonanoic acid at a concentration of 20 ppm (7.7 gal/acre). The third group was treated with a formulation of GB-1356 (0.5 gal/acre) and nonanoic acid (20 ppm or 7.7 gal/acre). Petroleum oil was applied at a rate lower than that recommended so that the joint action of nonanoic acid and the oil could be determined. Using twice this rate of oil would result in almost complete kill of larvae in the treated ponds.

EXPERIMENT 2. Three sets of ponds were treated with nonanoic acid only at concentrations of 40 (15.4 gal/acre), 20 (7.7 gal/acre) and 10 ppm (3.85 gal/acre) to determine a range of larvicidal and ovipositional action.

EXPERIMENT 3. One group was treated with

GB-1356 at the rate of 0.5 gal/acre, another with nonanoic acid (10 ppm or 3.85 gal/acre), and the last group of ponds with a formulation of GB-1356 (0.5 gal/acre) and nonanoic acid (10 ppm or 3.85 gal/acre).

RESULTS AND DISCUSSION

EXPERIMENT 1. Results of the first experiment are shown in Table 1. Two days after treatment, both the oil and nonanoic acid were singly and in combination effective in reducing egg laying on treated ponds. First- and 2nd-instar larvae were significantly reduced by these 3 treatments, but 3rd- and 4th-instar larvae and pupae were markedly reduced only in the treatments with nonanoic acid. When oil and acid were used in combination, populations of all immatures (eggs, larvae, and pupae) were significantly suppressed as compared to the untreated plots.

At 4 days post-treatment, the ponds treated with nonanoic acid had significantly fewer 3rd- and 4th-instar larvae than either the check or oil-only ponds; the oil-treated ponds had significantly fewer larvae than the check ponds. Also at 4 days, the ponds treated with oil, acid or acid-oil combination had significantly fewer pupae than the check ponds. At 7 days, the treated ponds had significantly lower numbers of all immature stages than those in the check ponds.

EXPERIMENT 2. During the tests with nonanoic acid at various concentrations, very little egg-laying was noted in either the test or check ponds. The effect of nonanoic acids at various rates on 3rd- and 4th-instar larvae and pupae is shown in Fig. 1. At 1-day post-treatment, both 20- and 40-ppm treated ponds contained reduced numbers of immatures as compared to the check ponds. By 2 days post-treatment, no immatures were present in either the 20- or 40-ppm treated ponds. By 5 days post-treatment, mosquito populations in all ponds including the checks declined to nil. This reduction was probably due to the action of natural enemies and other factors.

EXPERIMENT 3. As previously stated in experiment 2, 20- and 40-ppm nonanoic acid reduced the number of immature mosquitoes while at 10-ppm, a lower level of reduction was observed. The purpose of this experiment was to determine the effect of nonanoic acid at the low rate of 10-ppm in combination with the oil formulation. Results of this study are shown in Table 2. At 1 day post-treatment, the 1st- and 2nd-instar larvae were significantly reduced by the oil and acid combination. At 3 days post-treatment, the ponds treated with the combination had fewer immatures than the check ponds, but the numbers were not significantly

Table 1. Evaluation of nonanoic acid and GB-1356 (larvicidal oil) against *Culex* mosquitoes.[1]

	Mean no. egg rafts/pond, larvae & pupae/5 dips[2]			
Treatment and rate	Egg rafts	1st & 2nd	3rd & 4th	Pupae
		Pre-treatment		
Check	19a	106a	169a	27a
Oil 0.5 gal/acre	17a	67a	108a	10a
Acid 20 ppm	13a	54a	65a	8a
Oil 0.5 gal/acre + acid 20 ppm	21a	132a	118a	43a
		2 days post-treatment		
Check	32b	49b	111b	11b
Oil 0.5 gal/acre	4a	4a	51b	8b
Acid 20 ppm	3a	4a	1a	1a
Oil 0.5 gal/acre + acid 20 ppm	1a	1a	3a	1a
		4 days post-treatment		
Check	18a	19a	144c	12b
Oil 0.5 gal/acre	5a	6a	37b	2a
Acid 20 ppm	6a	1a	0a	0a
Oil 0.5 gal/acre + acid 20 ppm	3a	2a	1a	0a
		7 days post-treatment		
Check	12a	28b	181b	36b
Oil 0.5 gal/acre	2a	12a	12a	6a
Acid 20 ppm	2a	2a	1a	0a
Oil 0.5 gal/acre + acid 20 ppm	4a	2a	0a	0a

[1] Species composition: *Cx. peus* 80% and *Cx. tarsalis* 20% as based on larval determinations.
[2] Means (based on 3 replicates) in a column for each sampling period followed by same letters are not significantly different from one another at the 5% probability level.

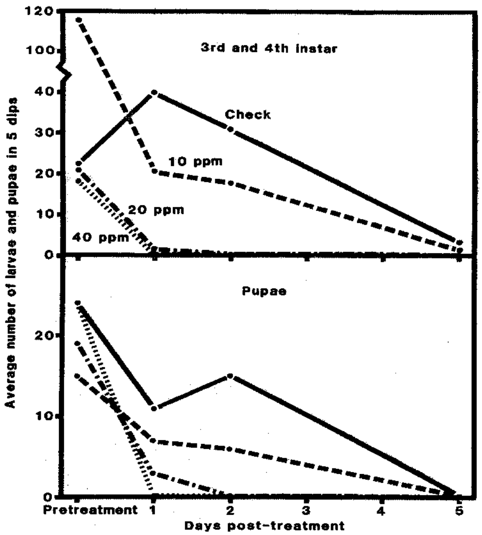

Fig. 1. Effects of nonanoic acid on the survival of 3rd and 4th-instar larvae and pupae of mosquitoes. Species were *Culex peus* (90%) and *Cx. tarsalis* (10%).

different. This is probably due to lack of recruitment and breeding of mosquitoes in the ponds at this time. The density of immatures in the check ponds was so low that differences due to treatment would not be detected.

These studies showed that, under field conditions, nonanoic acid alone at 20-ppm was effective in reducing the number of immature mosquitoes. The treated ponds with both materials showed ovipositional repellency and therefore had fewer eggs rafts than the check ponds for 7 days after treatment in experiment 1. The duration of efficacy in experiment 3, however, could not be determined due to lack of mosquito breeding. The formulation of nonanoic acid in petroleum oil initially caused mortality in larvae and pupae and subsequently showed ovipositional repellency in the treated ponds for several days, thereby keeping the mosquito populations at a low level for a somewhat longer period than the oil alone. Nonanoic acid alone or in combination with the larvicidal oil (GB-1356) can eliminate or reduce pupae in treated ponds; thus interrupting the progression of mosquito life cycle to the adult stage. It seems that this acid at 20 ppm alone or in combination with 0.5 gal/acre of GB-1356 can provide satisfactory short-term control of some *Culex* species.

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Table 2. Evaluation of nonanoic acid and GB-1356 singly and in combination as oviposition repellents and larvicides against *Culex* mosquitoes.[1]

Treatment and rate	Mean no. egg rafts/pond, larvae & pupae/5 dips[2]			
	Egg rafts	1st & 2nd	3rd & 4th	Pupae
		Pre-treatment		
Check	10a	36a	131a	0a
Oil 0.5 gal/acre	9a	13a	77a	0a
Acid 10 ppm	6a	19a	44a	0a
Oil 0.5 gal/acre + acid 10 ppm	4a	109a	116a	0a
		1 day post-treatment		
Check	8a	20b	90a	0a
Oil 0.5 gal/acre	1a	5b	6a	0a
Acid 10 ppm	4a	10b	42a	0a
Oil 0.5 gal/acre + acid 10 ppm	2a	0a	2a	0a
		3 days post-treatment[3]		
Check	7a	5a	14a	11a
Oil 0.5 gal/acre	3a	2a	10a	5a
Acid 10 ppm	5a	2a	12a	2a
Oil 0.5 gal/acre + acid 10 ppm	4a	4a	1a	1a

[1] Species composition: *Cx. tarsalis* 60% and *Cx. peus* 40%.

[2] Means (3 replicates) for each date in a column followed by same letter are not significantly different from one another at the 5% probability level.

[3] Lack of significant differences between the treatments and check is probable.

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SURVIVAL AND PREDATORY EFFICIENCY OF *GAMBUSIA AFFINIS* FOR CONTROL OF MOSQUITOES IN UNDERGROUND DRAINS

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ABSTRACT. Mosquitofish, *Gambusia affinis,* survived in an impounded water area within an underground storm drain system in Fresno, CA through a 14-wk period during the summer of 1982. The number and relative condition (K-factor) of the stocked fish slowly declined with the depletion of the food supply, as determined by fish gut content analysis, at the tenth week after introduction. However, the mosquitofish were effective in reducing the number of adult *Culex quinquefasciatus* produced in the drain system. Reductions of 75, 89 and 94% below those of an untreated control area were obtained after the first, second and third month, respectively. While female mosquitofish (gravid before introduction) produced offspring, no mating of fish within the drain was found.

INTRODUCTION

As urban sprawl displaces agriculture and destroys natural habitats, the production of some mosquito species is diminished. With a reduction in breeding habitat, such species as *Culex tarsalis* Coquillett and the floodwater *Aedes* spp. decrease in numbers. This is not the case for *Cx. quinquefasciatus* Say, which is proliferating in the breeding habitats provided by urbanization. A major breeding source in the urban environment is the underground storm drain system.

Chemical applications in storm drains cannot be solely relied upon because of the potential for insecticide resistance (Mulligan and Schaefer 1981). Physical and biological methods which show potential should be incorporated into an integrated control program. One example is a physical barrier system which prevents access of mosquitoes to potential breeding areas within the drain line (Mulligan and Schaefer 1982).

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Complementing this integrated approach is the preliminary report by Farley and Caton (1982) on the success of the mosquitofish, *Gambusia affinis* (Baird and Girard) in underground drains. The following report is a further investigation into the predatory efficiency and survival potential of *G. affinis* in underground storm drain lines in Fresno, CA.

MATERIALS AND METHODS

The study areas were sections of a single, underground storm drain line, totaling ca. 3.5 km in length (Fig. 1). Two separate water impoundments were formed by flow barriers in the drain line. One impoundment included the entire upper 1.5 km portion of the line. A second, 0.7 km long impoundment was formed above a barrier located 1.3 km downstream from the first.

Adult mosquito populations were monitored by collections with miniature, CDC-type traps (Bio-Quip #2802 EVS) without CO_2 bait. Traps were operated overnight (ca. 1600 hr–0900 hr) with new batteries at each use. A single trap was placed in three manhole chambers in the two water impoundment areas. Species and num-