INFLUENCE OF WATER TEMPERATURE AND SURFACE CHARACTERISTICS ON THE LARVICIDAL ACTIVITY OF SURFACE TREATMENTS

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ABSTRACT. The influence of temperature on the larvicidal efficacy of 4 petroleum derivatives was evaluated. It was found that substantially higher mortality of all instars of *Aedes aegypti* and *Culex quinquefasciatus* occurred at water temperatures of 90° F as compared with those of 70° F. This enhanced activity was a function of accelerated development. Effectiveness of these petroleum hydrocarbons against the larvae of both species was found to be greater in polluted water prepared with Purina laboratory chow than in distilled water. The higher mortality in polluted water was associated with a greatly reduced dissolved oxygen content.

It is well known among mosquito control workers that the success obtained with the use of larvicides depends to a considerable extent upon the characteristics of the water to be treated, and upon the type and amount of vegetative cover present. Where the growth of emergent and/or floating vegetation is heavy, dosages generally have to be increased for effective kill. In the case of organophosphorous larvicides, two additional problems have arisen. One is the relatively rapid loss of effectiveness of applications to heavily polluted water. The other is the well-recognized problem of resistance in many areas where larvicides have constituted the principal control modality.

With the increased interest in and use of petroleum type control agents, we have continued to conduct laboratory studies which are aimed at providing new information of value to field workers. More recently we have concentrated our efforts upon determining the relationships between certain water characteristics, i.e., temperature and pollution, and the efficacy of newer petroleum derivatives which do not appear to induce resistance.

With regard to the temperature factor, our preliminary studies in 1968 with FLIT MLO indicated that in general, its activity against certain species increased with increasing temperature (Micks, *et al.,* 1968). However, this phenomenon was not explored further at the time, and the reasons for it were not known. Starting about 8 months ago, we began an in-depth study of the effect of water temperature upon the efficacy of this commercially available control agent and several newer experimental materials also derived from petroleum.

Materials and Methods. The first series of experiments was conducted at 70° F, 80° F, 90° F, and 100° F. We found that (1) a 10-degree differential did not provide the magnitude of biological effect we were seeking, and (2) that the untreated control mortality at 100° F was too high to permit valid comparisons. Consequently, all subsequent experiments were run at 70° F and 90° F, respectively, using three replicates of 25 larvae/beaker for each temperature and each of the 4 petroleum hydrocarbons (5398–2, 5337–2, 5337–4 and 3855–2) tested at the rate of one-half gallon/acre against all larval instars of *Culex quinquefasciatus* and *Aedes aegypti*. The newer petroleum derivatives used are similar to FLIT MLO (3855–2), having a minimum initial boiling point of 500° F and minimum unsulfonated residue of 90 volume percent, but varied from 3855–2 in their paraffinic hydrocarbon structure and surface-active properties. Three series of experiments were done and the mortalities obtained at intervals of 1, 2 and 7 days were averaged. The results obtained with the various instars were very similar. Consequently, only those with a single instar (3rd) are presented here.

The other water characteristic studied

was pollution and its effect on mortality following application of the test materials to the water surface. Our standard polluted water was prepared by using 50 grams of ground Purina laboratory chow per 2500 ml. of tap water and incubating the mixture in battery jars for one week at 80° F and 80% R.H. before use. This stock was used at a series of dilutions in initial experiments and the ratio 238 ml. of distilled H_2O to 12 ml. of stock was selected as the maximum level of pollution, i.e., the highest level which would not cause larval mortality in untreated controls. Four replicates of 25, 4th instar larvae per beaker were included for each of the 4 petroleum hydrocarbons (5398–2, 5337–2, 5337–4 and 3855–2) which were applied at the rate of 1 gal/acre in both the laboratory-prepared polluted water and distilled water. Corresponding untreated controls were set up in two replicates (50 specimens). The percent mortality and dissolved oxygen (DO_2) concentration in both the experimental and control beakers were recorded at intervals of 1, 2, 4 and 7 days. The DO_2 readings of each group of replicates were averaged. Because similar findings were obtained with the 4 petroleum derivatives, only the results with 5337–4 are presented.

RESULTS AND DISCUSSION. It can be seen that the mortality of *A. aegypti* larvae following these surface treatments was at least 2- to 3-fold higher at 90° F, at least during the first 48 hours of the exposure period (Table 1). This same temperature effect was much more dramatic with the *C. quinquefasciatus* larvae (Table 2). Since we knew of no reason why a differential of 20° F in temperature would alter the biological activity of the test material we suspected that accelerated development at 90° F was probably an important factor. Thus keeping daily records of the number of larval skins/beaker in subsequent experiments showed that during the effective life of the surface film (24–36 hours), both 3rd and 4th instars were present in the 90° F beakers. This coupled with the greater susceptibility of the 4th instar larvae to these derivatives as determined in earlier work (Micks, *et al.*, 1968), explained the higher mortality

TABLE 1. Percent mortality in 3rd instar *A. aegypti* larvae treated at the rate of ½ gal/acre.*

	1 day		2 days		7 days	
Agent	70° F	90° F	70° F	90° F	70° F	90° F
5398–2	0.3	3	4	15	17	34
5337–2	0.3	13	7	27	40	54
5337–4	1	2	3	8	22	27
3855–2	0.3	2	1	8	14	43

* Less than the recommended dose was used to increase survival for better comparison of temperature effects.

TABLE 2. Percent mortality in 3rd instar *C. quinquefasciatus* larvae treated at the rate of ½ gal/acre.*

	1 day		2 days		7 days	
Agent	70° F	90° F	70° F	90° F	70° F	90° F
5398–2	0	8	3	40	75	55
5337–2	0	5	3	40	52	60
5337–4	0	3	5	40	29	68
3855–2	0	4	1	47	45	72

* Less than the recommended dose was used to increase survival for better comparison of temperature effects.

at higher temperatures. Thus, it is reasonable to expect that the field application of petroleum derivatives such as we evaluated would provide enhanced control during the summer months when water temperatures are highest.

As shown in Figure 1, maximum mortality of *C. quinquefasciatus* larvae occurred much more quickly (24 hours) in polluted water than in distilled water. In addition, the 7-day mortality was 10 percent higher in the polluted water, reaching 93 percent. Whereas the DO_2 content of the polluted water was low, not exceeding approximately 3 ppm during the first 24 hours after treatment, the DO_2 level of the distilled water remained above 7 ppm. Similar results were obtained with *A. aegypti* larvae with the striking exception that the mortality was more than 50 percent higher in the polluted water (Figure 2).

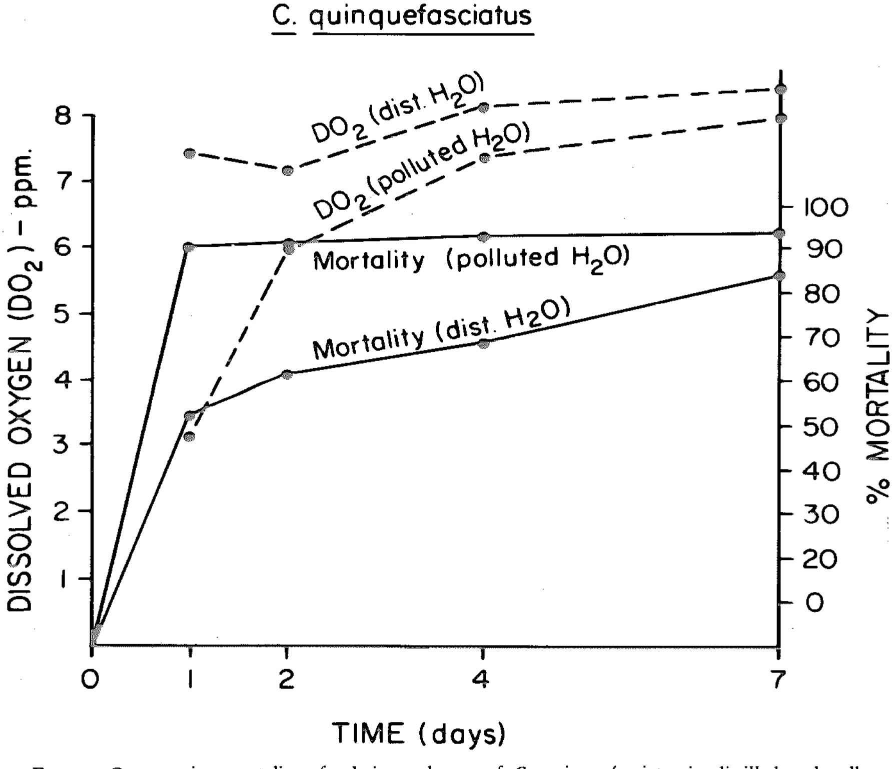

FIG. 1. Comparative mortality of 4th instar larvae of *C. quinquefasciatus* in distilled and polluted water and corresponding dissolved oxygen levels following treatment of the water surface with 5337–4 (1 gal/acre). Measurements obtained with DO meter, Model 51, Yellow Springs Instr. Co., Inc.

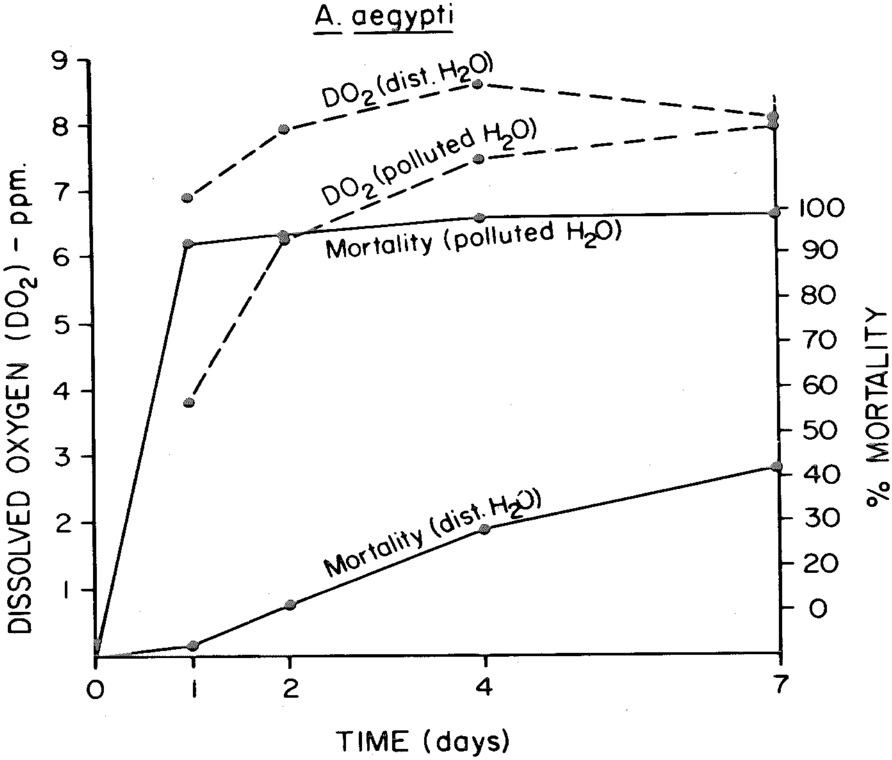

FIG. 2. Comparative mortality of 4th instar larvae of *A. aegypti* in distilled and polluted water and corresponding dissolved oxygen levels following treatment of the water surface with 5337–4 (1 gal/acre).

The higher mortality in polluted water was associated with, if not due to, the relatively low DO_2 levels during the 24-hour period following treatment. These results indicate that as long as the petroleum hydrocarbon can reach the surface of a polluted, mosquito breeding area, larval mortality should occur more quickly and reach a higher level as compared with other situations at the same dosage. Furthermore, the fact that petroleum derivatives of the type used in this study do not appear to induce resistance represents an additional advantage over conventional larvicides used in volumetric treatments (Micks and Gaddy, 1973).

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SYNERGISM OF PYRETHROIDS USED AS ADULTICIDES AGAINST *AEDES TAENIORHYNCHUS* (WIEDEMANN)[1]

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ABSTRACT. Laboratory wind tunnel tests showed that the synergists piperonly butoxide, sulfoxide, and Tropital® (piperonyl bis[2-(2-butoxyethoxy)ethyl] acetal) increased the effectiveness of resmethrin, pyrethrins, and tetramethrin 1.8 to 12.5-fold, depending primarily on the ratio of pyrethroid to synergist. The synergism would greatly decrease the cost of adult control with these pyrethroids.

We recently reported that pyrethroid compounds synergized at a 1:5 ratio with piperonyl butoxide were 5.8 to 6.3 times as effective as pyrethroids used alone in controlling a black salt-marsh mosquito, *Aedes taeniorhynchus* (Wiedemann), one of the principal pest species in the coastal areas of the southeastern United States (Mount and Pierce 1973). Because of the relatively low cost of synergists compared with that of pyrethroids, we investigated the effect of combining pyrethroids with synergists at ratios of 1:1 to 1:25.

METHODS AND MATERIALS. The three pyrethroids tested were pyrethrins, resmethrin, and tetramethrin. The synergists, piperonyl butoxide, sulfoxide, and Tropital® (piperonyl bis[2-(2-butoxyethoxy) ethyl] acetal), were used at ratios of 1, 2.5, 5, 10, and 25 parts to 1 part pyrethroid (w/w).

The combinations were tested as contact sprays in a wind tunnel, a cylindrical tube 4 inches in diameter through which a column of air is drawn at a speed of 4 miles per hour by a suction fan. In each test, 25 female mosquitoes from the laboratory colony were confined in a tubular galvanized metal cage with screened ends and placed in the center of the tube. Then, 0.25 ml of a solution of the chemicals in deodorized kerosene was atomized at a pressure of 1 pound per square inch into the mouth of the tunnel, and the mosquitoes were exposed momentarily to the droplets as they were drawn through the cage. Duplicate cages were used in each test, and 2 to 5 tests were made with each concentration of each combination. After treatment, the mosquitoes were anesthetized with carbon dioxide, transferred to cardboard holding cages, and furnished with a 10 percent sugar-water solution. Mortality counts were made 24 hours after exposure. Mosquitoes handled in the same manner and exposed to deodorized kerosene only showed <5 percent mortality.

RESULTS AND DISCUSSION. The increases in effectiveness of the pyrethroid-synergist combinations compared with the effectiveness of the unsynergized pyrethrins are shown by the LC_{90} reciprocal ratios in Table 1. These increases ranged from 1.8

[1] This paper reflects the results of research only. Mention of a pesticide or an endorsement of a proprietary product in this paper does not constitute a recommendation or an endorsement of this product by the USDA.