Developing better larvicides

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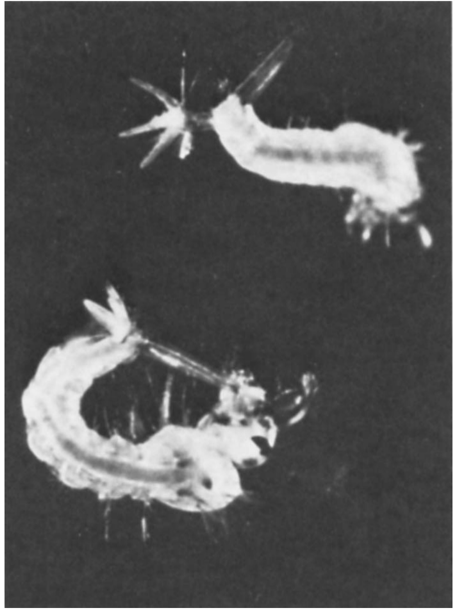

Mosquito larvae curl up in futile attempt to clear their siphon tubes of larvicidal oil.

The diversity of California mosquitoes and their habitats and the ever-present problem of resistance to chemicals necessitated the development of the effective formulations of petroleum oils and long-chain aliphatic amines currently used in large-scale mosquito control programs. Also, some highly effective synthetic pyrethroids recently have become available for control of immature stages of mosquitoes.

Petroleum oil larvicides

The recorded use of petroleum products against mosquitoes goes back to the end of the last century, when kerosene was used for larval control. Systematic University of California research on petroleum oil larvicides, begun in the 1920s, produced some relatively effective oil formulations from special oil fractions, diesel oils, and crankcase oils.

Research on petroleum oils received greater impetus in the late 1960s and early 1970s, when important mosquitoes in California developed immunity to organophosphate insecticides. Such research has significantly reduced the cost of mosquito control with larvicidal petroleum oils. In the 1930s the cost ranged from $2.00 to $6.85 per acre. Today, because of the highly effective formulations, the cost per acre is only $2.00 to $3.00, despite the manyfold increase in costs of goods and services. Currently, more than 600,000 gallons of specially formulated petroleum hydrocarbons are used in California mosquito control programs.

The larvicidal activity has been greatly increased by blending certain fractions and by adding surfactants or detergents in small quantities, which change the surface tension of the oil as well as the water surface to which it is applied. Most of the larvicidal oils are paraffinic or isoparaffinic fractions and contain 0.5 to 1 percent surfactants. Fractions containing large amounts of aromatic hydrocarbons generally are not used because of their inherent phytotoxicity. Today, using the special formulations, effective mosquito control can be obtained by applying as little as 1 to 2 gallons per acre.

The petroleum larvicidal oils have several advantages over synthetic larvicides. Even though they have been used for more than 80 years, no resistance to these oils has yet developed in mosquitoes. Additionally, the larvicidal oils have little or no toxicity to applicators and pose relatively few ecological hazards in aquatic ecosystems.

Aliphatic amines

Aliphatic amines are chemicals generally derived from animal fats and vegetable oils. They have detergent-like activity and change the surface phenomena of water, mosquito larvae, and other organisms. Although their mode of action is not known, the aliphatic amines seem to affect mosquito larvae and pupae in the same manner as do the petroleum hydrocarbon larvicides.

Although they have not been developed *per se* as mosquito control agents, aliphatic amines (0.5 to 3 percent) are incorporated in several petroleum oil formulations, greatly increasing their activity as larvicides and reducing their cost. However, aliphatic amines themselves are a diverse group of simple chemicals toxic to larvae and pupae, and would be economically feasible to use for mosquito control where resistance to conventional insecticides is prevalent.

Synthetic pyrethroids

During the past 20 years, a fairly large number of synthetic pyrethroids (related to the natural pyrethrins) have been studied for insect control. Nearly all showed a high level of activity against adult mosquitoes but little or none against mosquito larvae in aquatic habitats. Because most control operations in California are aimed at immature mosquitoes, synthetic pyrethroids have provided no relief against organophosphate-resistant mosquitoes.

Several newer synthetic pyrethroids, however, have recently become available for experimentation against insect pests. Unlike their older relatives, these pyrethroids are stable under light and highly effective against mosquito larvae. An additional feature, which makes these compounds highly desirable in mosquito control programs, is their high level of activity against mosquito pupae; with a little increase in the effective larvicidal rates, they also control pupal populations. Using the synthetic pyrethroids, one can delay treatment for 2 to 3 days, after which the breeding sources will be greatly diminished, requiring less effort and material for application.

Among the new generation of synthetic pyrethroids are several compounds that have shown a very high level of activity in our research, particularly decamethrin, permethrin, and sumithrin. The LC_{90} (concentration killing 90 percent of larvae) of decamethrin is in the range of 0.045 to 0.9 part per billion. This is the most effective compound ever tested against mosquitoes. Permethrin and sumithrin also are very effective, especially against organophosphate-resistant mosquitoes.

Although resmethrin showed a very high level of activity against mosquito larvae in the laboratory, it failed to control larval mosquitoes at practical dosages in the field. As in the laboratory, decamethrin controlled 90 to 100 percent of the larvae at the very low rates of 0.00025 to 0.005 pound per acre (less than a teaspoonful per acre), under a variety of field conditions. Although higher rates of permethrin and sumithrin were required for 90 to 100 percent control (0.01 to 0.05 pound per acre of permethrin and 0.025 to 0.1 pound of sumithrin), both are still considered to have excellent activity against field populations of mosquitoes.

As mentioned earlier, the new synthetic pyrethroids, unlike many other mosquito larvicides, have excellent activity against mosquito pupae. If developed and registered for use against mosquitoes, they will definitely mitigate some of the current difficulties encountered in mosquito control programs.

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