EFFECTS OF FARNESOL AND ZIRAM ON MOSQUITO LARVAE

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Farnesol [1] (3,7,11-trimethyl 2,6,10-duodecatriene-1-ol) and ziram [2] (zinc dimethyldithiocarbamate) are purported to affect insect hormonal systems. Wigglesworth (1961) indicated that the long chain alcohol, farnesol, had a juvenile-hormone-like effect on the bug *Rhodnius prolixus* Stål. Gretillat (1962) indicated that ziram killed mosquito larvae by retarding or preventing metamorphosis. This suggests that ziram may be blocking or preventing the molting hormone (ecdysone) from acting.

Studies on the effects of chemicals with modes of action unrelated to present-day insecticides appear to be in order, since increasing numbers of cases of insecticide resistance are being reported in economically important species.

Mosquito larvae are well suited for studies on the biological effects of chemicals. The use of mosquito larvae in insecticidal bioassays has been well established. The observed effects of farnesol and ziram on *Culex pipiens quinquefasciatus* Say fourth instar larvae are reported in this paper.

MATERIALS AND METHODS. Farnesol and ziram prepared as 1.0 percent wt/vol. stock solutions were diluted serially with acetone to obtain concentrations that when added to water gave a final concentration of from 0.05 to 10.0 p.p.m. of active ingredient.

Twenty fourth instar larvae of *C. p. quinquefasciatus* were transferred to 100 ml. of distilled water in a four-ounce paper cup for each treatment. The tests were run in triplicate at each concentration; three batches of larvae were used to obtain the averages indicated in the tables. Treated larvae were held for 24 hours and mortality observations were made at this time. Additional observations of larval mortality were made at 48 and 72 hours. After the first 24 hour period, surviving larvae were fed high protein supplement pellets; [3] no food was available during the first 24 hours of exposure.

Larvae were treated by pipetting one ml. of acetone solution at the desired concentration into each cup. Controls (1 ml. acetone/100 ml. water) were run with each set of treated larvae. Mortality in the control was negligible over the observation period. Observations on larval mortality were made for 3 days; an additional 3 days of observations were made on pupation-delaying effects. All tests were made at 70° F.

RESULTS. The results of tests conducted with farnesol and ziram are shown in Tables 1 and 2. When fourth instar larvae were treated with 10.0 p.p.m. of farnesol or ziram, 80 percent to 100 percent mortality occurred in 24 hours. The use of lethality as a criterion, however, does not necessarily indicate that mortality resulted from hormone-like activity. This seems especially true of farnesol, because if it is acting as a hormone-like substance, it is surprisingly toxic to mosquito larvae. A toxic effect on the pupal stage was also noted with farnesol.

Lower dosages of farnesol and ziram prolonged the fourth larval stadium. The period required for complete pupation was increased an additional day by dosages of farnesol ranging from 0.1 to 1.0 p.p.m. Ziram at 5.0 to 10.0 p.p.m. produced an even greater effect on prolonging the fourth larval stadium; in one test,

[1] L. Light and Co., Ltd., Poyle Estate, Colbrook, Bucks, England.
[2] E. I. duPont de Nemours and Co., Wilmington, Delaware.
[3] Misco Mills, Bozeman, Montana.

TABLE 1.—Effect of farnesol on 4th instar larvae of *Culex pipiens quinquefasciatus*.

Days after treatment	Conc. p.p.m.[a]	Larval mortality accumulative total on day indicated for each 24 hour period	Days after treatment	Accumulative total for percent pupation of surviving larvae on day indicated
1st day (24 hrs.)	Control (untreated)	0	4th day	34
	0.05	0		26
	0.1	15		24
	1.0	45		7
2nd day	Control	0	5th day	88
	0.05	3		71
	0.1	25		64
	1.0	70		61
3rd day	Control	0	6th day	100
	0.05	7		82
	0.1	30		75
	1.0	75		70

[a] At 10.0 p.p.m. farnesol produced 75–80 percent mortality in 4th instar larvae by 24 hours. Considerable mortality of pupae also occurred when surviving larvae were allowed to pupate (3 to 4 days after treatment).

TABLE 2.—Effect of ziram on 4th instar larvae of *Culex pipiens quinquefasciatus*.

Days after treatment	Conc. p.p.m.[a]	Larval mortality accumulative total on day indicated for each 24 hour period	Days after treatment	Accumulative total for percent pupation of surviving larvae on day indicated
1st day (24 hrs.)	Control (untreated)	0	4th day	60
	0.5	0		45
	1.0	5		30
	5.0	60		7
	10.0	81		..
2nd day	Control	0	5th day	96
	0.5	0		51
	1.0	5		62
	5.0	65		38
	10.0	100		..
3rd day	Control	0	6th day	100
	0.5	10		98
	1.0	16		96
	5.0	67		45
	10.0	100		..

[a] In one test concentrations of 5.0 and 10.0 p.p.m. produced 65 and 85 percent mortality of larvae respectively by 6 days after treatment. At 8 days after treatment the control had completely pupated but the surviving treated larvae were still 4th instar. An additional 5 days were required for complete pupation of these larvae.

surviving larvae treated at 10.0 p.p.m. (85 percent mortality 24 hrs.) remained in the larval stage for five days after control larvae had pupated.

DISCUSSION. According to Karlson (1962) metamorphosis to the adult stage occurs in insects when the titer of neotenin (juvenile hormone) is low or absent, thus allowing ecdysone (molting hormone) to act alone. As long as a high titer of neotenin remains with ecdysone, immature characters are retained.

In the tests performed with mosquito larvae, perhaps enough farnesol was absorbed by the larva to create a large amount of neotenin or neotenin-like substances in the presence of ecdysone for a longer period than ordinarily occurs, thus resulting in a delay of pupation.

The pupation-delaying effects of ziram are brought about by interfering with the normal process of metamorphosis. This compound may block or tie up ecdysone and prevent it from acting although no experimental evidence to support this thesis is presented in this paper.

The results obtained with farnesol and ziram offer promise of an intriguing new approach to the chemical control of insects. Prolongation of the larval stage with certain rapid-growing species of mosquitoes such as *Aedes nigromaculis* (Ludlow) may be sufficient for temporary sources of water to dry out, thus stranding larvae and in this manner bringing about control. The commercial possibilities of farnesol or ziram as mosquito control agents remain in question at this point.

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