OPERATIONAL AND SCIENTIFIC NOTES

EFFICACY AND PERSISTENCE OF SUSTAINED-RELEASE METHOPRENE PELLETS AGAINST *AEDES* MOSQUITOES IN AN IRRIGATED PASTURE

VICKI L. KRAMER AND CHARLES BEESLEY

Contra Costa Mosquito Abatement District, 155 Mason Circle, Concord, CA 94520

ABSTRACT. The efficacy and persistence of sustained-release methoprene (Altosid®) pellets were evaluated at rates of 3.4 and 9.0 kg/ha against *Aedes* mosquitoes through 7 flood cycles (126 days) in an irrigated pasture. At both rates, the pellets provided greater than 98% control through 2 flood cycles, or 20 days posttreatment, and greater than 80% control through 5 flood cycles, or 69 days posttreatment.

The insect growth regulator, methoprene, inhibits ecdysis of the mosquito pupa to the adult. Methoprene is a selective control agent and has little impact on nontarget organisms, including most mosquito predators (Miura and Takahashi 1973, Creekmur et al. 1982). Methoprene is available in several Altosid® formulations, including liquids and briquets. However, these formulations have some limitations. For instance, the liquid formulation has very little residual activity (Schaefer and Dupras 1973, Mulla and Darwazeh 1975) and cannot be applied prior to the flooding of a mosquito source. The briquet formulations have residuals of up to 30 or 150 days (according to the product labels), and they can be applied prior to the inundation of a mosquito habitat. However, the briquets are designed to control mosquitoes in small bodies of water and are impractical to use in large habitats such as marshes and irrigated pastures.

Methoprene has recently been formulated as sustained-release pellets. These pellets distribute the methoprene more evenly than the briquets because the active ingredient is released from many point sources. They are therefore more appropriate for large mosquito habitats. The pellets have been evaluated in experimental brackish ponds in Florida (Floore et al. 1990) and flooded grassland depressions (dambos) in Kenya (Linthicum et al. 1989, Logan et al. 1990), where they effectively controlled mosquitoes for about 30 and 21 days, respectively. This study evaluated the efficacy and persistence of the methoprene sustained-release pellets through several flood cycles in an irrigated pasture.

An irrigated pasture in eastern Contra Costa County, CA, was selected as the study site. The pasture was 1.3 ha and was divided into 20 (0.063 ha, 8 × 79 m) parallel plots. Water entered each plot from a ditch running perpendicular to the plots, and runoff water was collected at the opposite end of the plots by a tailwater ditch. The pasture was flooded approximately every 2–3 wk but was dry for at least several days between floodings. Cattle were excluded from the pasture except during the fourth flood cycle when the pasture was required for grazing.

Every other plot was randomly assigned one of 3 treatments: 3.4 kg/ha (3 lbs/acre) methoprene pellets (RF-330 Altosid® pellets, Zoecon Corporation, Dallas, TX), 9.0 kg/ha (8 lb/acre) methoprene pellets, or control. There were 3 replicates of each treatment. The sustained-release pellets, which consisted of 4% methoprene bound with activated charcoal, were applied on June 19, 1990, 4 days prior to flooding, with a hand operated Ortho Whirlybird® Spreader (Chevron Chemical Co., San Francisco, CA).

Emergence of *Aedes* mosquitoes was monitored through 7 flood cycles (126 days posttreatment). During each flood cycle, larvae developed in the pasture until most of the population reached the pupal stage. Approximately 150 fourth instar larvae and pupae were then collected from each plot with a standard (400 ml) dipper, and the number of dips taken in each plot recorded. The mosquitoes were placed in a bucket with pasture water from the same plot and brought to the laboratory. The collection was recounted to verify the field count and to determine the exact proportion of fourth instar larvae to pupae. The 9 buckets were then placed in individual emergence cages and the adults counted, sexed and identified as they emerged. The percent mortality was calculated as the number of pupae not successfully emerging/number of immatures in the sample times 100. One-way analysis of variance and Tukey's test (for pairwise comparisons, $P = 0.05$) were used to detect significant differences in the mortality rates among the 3 treatments. The arcsin transformation of the percent mortality was used in the analysis.

Species composition was determined for each flood cycle by combining the adult identification data with larval identification data derived from the separate collection of approximately 25 fourth instar larvae from each plot.

Immature mosquitoes were collected from the plots 6-10 days after flooding except during the fourth flood cycle, when insufficient irrigation resulted in the pasture drying up before the larvae reached the fourth instar. There were, therefore, no data for that flood cycle.

The average number of immature mosquitoes collected/dip ranged from 2.0 to 4.3, except during the fifth flood cycle, when pupae were highly concentrated in small pools of water and numbered about 100/dip. The average ratios of fourth larval instars to pupae collected for flood cycles 1-3 and 5-7 were 23:77, 10:90, 13:87, 1:99, 6:94 and 2:98, respectively.

Aedes melanimon Dyar, *Ae. nigromaculis* (Ludlow) and *Ae. vexans* (Meigen) were collected in the irrigated pasture and during the summer months (i.e., flood cycles 1, 2 and 3) represented an average of 38.1, 40.6 and 21.3% of the *Aedes* population, respectively. In September and October, *Ae. melanimon* was the predominate species, representing 83% of the *Aedes* population. Early instar *Culex tarsalis* Coq. and *Cx. pipiens* Linn. were also collected in the irrigated pasture but were not included in the study.

The percent mortality of the *Aedes* mosquitoes in the methoprene treated and control plots is given in Table 1. Emergence was minimal in the treated plots during the first 2 flood cycles, with mortality exceeding 98%. Mortality then decreased to 87.0 and 81.2% at the low and high treatment rates, respectively, during the third flood cycle.

During the fifth flood cycle, mortality increased to 93.0 and 97.0% for the low and high treatment rates, respectively. The water in each plot had drained into low-lying areas, and thus the pupae were highly concentrated. Methoprene concentrations in these pools may also have been high, perhaps explaining the increased percent mortality relative to the third flood cycle. Mortality decreased during the sixth and seventh flood cycles to between 73.9 and 58.7%.

Mortality in the control plots for flood cycles 1-3 and 5-7 averaged ca. 14, 3, 1, 6, 12 and 26%, respectively. During each flood cycle, the percent mortality in the plots treated with methoprene was significantly higher than in the control plots, but percent mortality between the low and high treatment levels was not significantly different.

Although this study was conducted for 126 days, the pellets were submerged for only about 73 days because the pasture was dry between floodings. Methoprene is released only when the pellets are wet; when the pellets are dry, the activated charcoal in the pellets protects the methoprene from ultraviolet radiation (Zoecon Corp., unpublished data). Therefore, the residual effectiveness of the pellets may be attributed, in part, to the intermittent dryness of this habitat.

In conclusion, both application rates of methoprene sustained-release pellets provided greater than 98% control of *Aedes* mosquitoes in an irrigated pasture through 2 flood cycles, or 20 days posttreatment, and greater than 80% control through 5 flood cycles, or 69 days posttreatment. Although these pellets are more expensive than many other mosquito larvicides currently available, the demonstrated persistence of this product may reduce the treatment frequency, resulting in potential cost savings.

We thank R. Slager for his technical support, and D. R. Mercer and A. E. Colwell for their comments on this manuscript. The authors also acknowledge D. Sullivan of Zanus Corporation for his review comments and for supplying the methoprene pellets.

Table 1. Efficacy of 4% methoprene pellets against *Aedes* spp. in an irrigated pasture at 2 treatment rates.

Flood cycle[1]	Days post-treatment[2]	Percent mortality[3] 3.4 kg/ha	9.0 kg/ha	Control
1	4	100.0	100.0	14.0
2	20	98.0	100.0	2.7
3	34	87.0	81.2	1.0
5	69	93.0	97.0	6.0
6	87	62.2	58.7	12.1
7	115	73.9	68.2	26.2

[1] Pasture dried up during 4th flood cycle before larvae reached the fourth instar.

[2] Number of days between treatment and date pasture was flooded.

[3] Number of pupae not successfully emerging/number of immatures collected times 100.

REFERENCES CITED

Creekmur, G. D., M. P. Russell and J. E. Hazelrigg. 1982. Field evaluation of the effects of slow-release wettable powder formulation of Altosid® on nontarget organisms. Proc. Calif. Mosq. Vector Control Assoc. 49:95-97.

Floore, T. G., C. B. Rathburn, Jr., A. H. Boike, Jr., H. M. Rodriguez and J. S. Coughlin. 1990. Small plot test of sustained-release Altosid® (methoprene) pellets against *Aedes taeniorhynchus* in brackish water. J. Am. Mosq. Control Assoc. 6:133–134.

Linthicum, K. J., T. M. Logan, P. C. Thande, J. N. Wagateh, C. W. Kamau, C. L. Bailey, F. G. Davies and J. P. Kondig. 1989. Efficacy of a sustained-release methoprene formulation on potential vectors of Rift Valley Fever virus in field studies in Kenya. J. Am. Mosq. Control Assoc. 5:603–605.

Logan, T. M., K. J. Linthicum, J. N. Wagateh, P. C. Thande, C. W. Kamau and C. R. Roberts. 1990. Pretreatment of floodwater *Aedes* habitats (dambos) in Kenya with a sustained-release formulation of methoprene. J. Am. Mosq. Control Assoc. 6:736–738.

Miura, T. and R. M. Takahashi. 1973. Insect developmental inhibitors. 3. Effects on nontarget aquatic organisms. J. Econ. Entomol. 66:917–922.

Mulla, M. S. and H. A. Darwazeh. 1975. Activity and longevity of insect growth regulators against mosquitoes. J. Econ. Entomol. 68:791–794.

Schaefer, C. H. and E. F. Dupras, Jr. 1973. Insect developmental inhibitors. 4. Persistence of ZR-515 in water. J. Econ. Entomol. 66:923–925.