CONTROL OF *AEDES TAENIORHYNCHUS* AND *CULEX QUINQUEFASCIATUS* EMERGENCE WITH SUSTAINED RELEASE ALTOSID® SAND GRANULES AND PELLETS IN SALTWATER AND FRESHWATER TEST PLOTS

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ABSTRACT. The efficacy of sustained release Altosid® sand granules to control adult *Aedes taeniorhynchus* and *Culex quinquefasciatus* emergence was investigated. Sand granules applied at a 7-day preflood application rate of 5.6 kg/ha controlled 99% of the *Ae. taeniorhynchus* emergence in saltwater plots for 44 days posttreatment and 35% of *Cx. quinquefasciatus* in freshwater plots. A 5.6 kg/ha rate controlled 100% of the *Ae. taeniorhynchus* emergence for 30 days posttreatment in semi-permanent saltwater plots. Altosid pellets were used at the label rate for comparison. Sand granules applied at 11.2, 16.8 and 22.4 kg/ha against *Cx. quinquefasciatus* in freshwater plots gave 98% emergence inhibition at the 22.4 kg/ha rate 37 days posttreatment, 93% at 16.8 kg/ha for 22 days, and 100% at 11.2 kg/ha rate for 16 days.

INTRODUCTION

Rathburn and Boike (1975) and Rogers et al. (1976) found Altosid® SR-10 (10% methoprene) formulated on sand at 5.6 kg/ha reduced emergence of *Aedes taeniorhynchus* (Wied.) by more than 93% and 10 kg/ha gave 100% emergence inhibition. Sjogren et al. (1986) and Walker (1987) reported that methoprene formulated as briquets was effective in controlling adult *Coquillettidia perturbans* (Walker) emergence. Floore et al. (1988) evaluated sustained release Altosid pellets (4% AI S-methoprene) both as a 15-day preflood application and direct application to standing water to control adult *Culex quinquefasciatus* Say emergence. The effectiveness of sustained release Altosid pellets (4% AI S-methoprene) applied directly in water to inhibit adult *Ae. taeniorhynchus* emergence was reported by Floore et al. (1990).

These studies were to determine the efficacy of S-methoprene formulated as sustained release Altosid sand granules (1.3% AI) designed to last 20 days. Sand granules were used against *Ae. taeniorhynchus* and *Cx. quinquefasciatus* as a 7-day preflood application, in a semi-permanent saltwater test against *Ae. taeniorhynchus* in a same day treatment, and at variable rates against *Cx. quinquefasciatus* in a same day treatment.

MATERIALS AND METHODS

The *Ae. taeniorhynchus* saltwater test plots were constructed in earthen cells (Rathburn and Boike 1975). To determine the correct dosage of Altosid sand granules or pellets to be applied, the saltwater plots were filled and the water surface area (ca. 18.6 m^2) of each plot measured. The 8 freshwater plots were concrete cells constructed above ground with a surface area of 9.3 m^2 each (Floore et al. 1988). The Altosid sand granules and pellets were weighed and applied by hand to randomly selected treatment plots in both the freshwater and saltwater studies. The amount of AI (S-methoprene) in the formulations was prepared by Zoecon. Application rates were also specified. Twice weekly, 400 ml of a larval food mixture of powdered liver and brewer's yeast (3:2) were added to each freshwater plot. The maximum and minimum air and water temperature and precipitation were recorded daily and the salinity once a week. In the first study (August 24 to October 7, 1989), sustained release Altosid sand granules (1.3% AI) and pellets (4% AI) were applied at 5.6 kg/ha (5 lb/acre) as a 7-day preflood application to both the saltwater and freshwater plots. Each test consisted of 3 replications of each test material and 2 untreated controls.

Approximately 3,000 laboratory reared first instar *Ae. taeniorhynchus* or *Cx. quinquefasciatus* larvae were placed in each of the respective plots weekly. About 100 pupae were collected from each plot weekly and held in styrofoam cups containing water from the respective plot. The containers were set in a sheltered area where the pupae were allowed to complete development. After emergence was completed, the number of cast pupal skins (CS), and dead pupae (DP), partially emerged adults (PE) and dead adults (DA) was counted, and the % emergence inhibition (EI) was determined using the following formula developed at the John A. Mulrennan, Sr. Research Laboratory:

$$\% \text{ EI} = 100 - \left(\frac{\text{CS} - \text{DA}}{\text{CS} + \text{PE} + \text{DP}} \times 100 \right)$$

Abbott's formula was applied to the data to correct for control mortality (Abbott 1925).

In the 2nd study (May 22 to June 21, 1990), the Altosid sand granules (1.3% AI) and pellets (4% AI) were applied at a rate of 5.6 kg/ha to flooded saltwater plots. Each treatment was replicated twice with 2 untreated controls. During the study, the plots were flooded 4 times and drained 3 times to simulate a semi-permanent environment. Each time the plots were drained, the Altosid formulations were exposed to the ambient conditions in a semi-permanent habitat for about 36 h.

Approximately 2,000 first instar *Ae. taeniorhynchus* larvae were placed in each plot after each flooding. Pupal collection and data assessment followed the procedure described above. Altosid pellets (4% AI S-methoprene) were used as a standard for comparison in these 2 studies.

In the 3rd study (June 3 to July 11, 1990), the 8 freshwater plots were filled and treated the first day with sand granules at application rates of 11.2, 16.8, and 22.4 kg/ha (10, 15, 20 lb/acre) and 100 *Cx. quinquefasciatus* egg rafts (approximately 100 eggs/raft) were placed in each plot. Each rate was replicated twice with 2 untreated controls. Each Monday, Wednesday and Friday, 100 egg rafts and 400 ml of larval food were added to each plot. Weekly pupal collection and data assessment were as described above.

Although an adequate asynchronous larval *Cx. quinquefasciatus* mosquito population was present throughout the 51-day test, sufficient numbers of pupae were not always present in each plot every day, and therefore some weeks pupal collections were made over several days.

RESULTS AND DISCUSSION

In the first study, no adult *Ae. taeniorhynchus* emergence was recorded in the saltwater plots treated with sand granules for 28 days posttreatment. Four percent emergence was recorded in one plot 37 days posttreatment and 2% emergence in the same plot 44 days posttreatment. In the saltwater plots treated with pellets, 100% emergence inhibition was recorded throughout the test. In the control plots, more than 98% of the adult *Ae. taeniorhynchus* emerged (Table 1).

In the freshwater plots treated with sand granules (Table 2), *Cx. quinquefasciatus* emergence inhibition did not exceed 39% during the study. The Altosid pellets controlled 92% emergence for 29 days, but was down to 74% 41 days posttreatment. Greater than 97% emergence was recorded in the control plots.

Two possible explanations for the granules' ineffectiveness in the freshwater plots were: 1) the amount of S-methoprene on the sand granule (1.3% AI vs. 4% AI for pellets) was not sufficient to disperse throughout the total water volume, and 2) the 5.6 kg/ha application rate was inadequate for effective emergence inhibition of *Cx. quinquefasciatus*. The freshwater plots had straight sides with a uniform water depth (ca. 25 cm) from edge to center. The randomly distributed granules settled to the bottom and the foraging or resting larvae may have spent less time in close proximity to the granules

Table 1. Efficacy of sustained release Altosid sand granules (1.3% AI S-methoprene) and pellets (4% AI) applied as a 7-day preflood rate of 5.6 kg/ha to control adult *Aedes taeniorhynchus* emergence in salt water plots.

Days post-treatment	Formulation	No. pupae sampled	Percent emergence inhibition ±SE
13	Granules	311	100.0 ± 0.0
	Pellets	348	100.0 ± 0.0
	Control	216	0.4 ± 0.3
21	Granules	331	100.0 ± 0.0
	Pellets	325	100.0 ± 0.0
	Control	220	0.5 ± 0.3
28	Granules	315	100.0 ± 0.0
	Pellets	326	100.0 ± 0.0
	Control	209	0.9 ± 0.7
37	Granules	317	98.1 ± 3.3
	Pellets	316	100.0 ± 0.0
	Control	205	0.0 ± 0.0
44	Granules	323	99.0 ± 1.7
	Pellets	309	100.0 ± 0.0
	Control	205	0.0 ± 0.0

Table 2. Efficacy of sustained release Altosid sand granules (1.3% AI S-methoprene) and pellets (4% AI) applied as a 7-day preflood rate of 5.6 kg/ha to control adult *Culex quinquefasciatus* emergence in freshwater plots.

Days post-treatment	Formulation	No. pupae sampled	Percent emergence inhibition ± SE
13	Granules	294	35.4 ± 10.7
	Pellets	318	100.0 ± 0.0
	Control	213	0.0 ± 0.0
24	Granules	322	39.0 ± 33.4
	Pellets	337	97.6 ± 3.3
	Control	211	1.0 ± 0.0
29	Granules	319	8.9 ± 4.6
	Pellets	315	92.4 ± 4.3
	Control	209	1.0 ± 1.4
35	Granules	314	6.9 ± 2.2
	Pellets	307	87.1 ± 2.8
	Control	218	1.4 ± 2.0
41	Granules	309	16.9 ± 10.8
	Pellets	310	73.7 ± 38.9
	Control	218	2.4 ± 2.1

than did the *Ae. taeniorhynchus* larvae in the saltwater plots, which were graded and the water depth gradually increased from the edge to ca. 25 cm in the center. Rathburn and Boike (1975) reported *Ae. taeniorhynchus* were more susceptible to S-methoprene than *Culex* species. Altosid pellets (4% AI S-methoprene) successfully inhibited emergence (92%) for 29 days posttreatment in the freshwater plots.

The salinity was 20 ppt at the start of the study and 4 ppt at the end ($\bar{X}$ = 12 ppt). The daily water temperature ranged from 22 to 34°C ($\bar{X}$ = 28°C) in the saltwater plots and 19 to 33°C ($\bar{X}$ = 26°C) in the freshwater plots. The recorded rainfall was 16.5 cm over the 44-day study.

In the 2nd study, where the plots were drained for about 36 h, then reflooded, both the Altosid sand granules and pellets gave 100% emergence inhibition of adult *Ae. taeniorhynchus* in each of the treated plots throughout the 30-day test (Table 3). More than 94% adult emergence was recorded in the control plots. No apparent degradation of the Altosid formulations effectiveness occurred in the 30-day semi-permanent study.

Less than 5 cm of rainfall was recorded during the study with no rain occurring during the drained periods. The water temperature ranged from 26 to 36°C ($\bar{X}$ = 30°C) and increased from an average of 24°C the first flooded period to 32°C the last. The ambient temperature ranged from 17 to 39°C ($\bar{X}$ = 28°C) with the last drained period 5°C higher than any flooded period. The average salinity was 20.5 ppt at the start of each flooding period and 9.5 ppt at the end.

The 3rd study compared 3 sand granule application rates against *Cx. quinquefasciatus* and indicated that the 11.2 kg/ha application rate was excellent for 16 days posttreatment (100% control), but less effective during the remainder of the study (Table 4). The 16.8 kg/ha treatment controlled 93% of the *Cx. quinquefasciatus* emergence for 22 days posttreatment, but control gradually decreased to 38% emergence inhibition 51 days posttreatment. With the 22.4 kg/ha rate, over 94% emergence inhibition was achieved for 37 days posttreatment; at 51 days posttreatment 72% emergence inhibition was recorded. More than 93% of the adult *Cx. quinquefasciatus* emerged in the control plots.

A comparison of the emergence inhibition efficacy of the sand granules and the pellets in the freshwater tests may be made using the pellet data in Table 2 and the sand granule data in Table 4. The granular application of 16.8 kg/ha contained 21.8% AI, and the pellet application at 5.6 kg/ha contained 22.4% AI. Though the pellets had been exposed to a 7-day preflood condition before flooding, their effectiveness to

Table 3. Efficacy of sustained release Altosid sand granules (1.3% AI S-methoprene) and pellets (4% AI) applied at 5.6 kg/ha to control adult *Aedes taeniorhynchus* emergence in saltwater plots.[1]

Days post-treatment	Formulation	No. pupae sampled	Percent emergence inhibition ±SE
5	Granules	213	100.0 ± 0.0
	Pellets	216	100.0 ± 0.0
	Control	217	6.0 ± 7.7
14	Granules	200	100.0 ± 0.0
	Pellets	206	100.0 ± 0.0
	Control	280	0.7 ± 1.0
22	Granules	212	100.0 ± 0.0
	Pellets	217	100.0 ± 0.0
	Control	208	1.0 ± 0.7
30	Granules	222	100.0 ± 0.0
	Pellets	221	100.0 ± 0.0
	Control	220	1.4 ± 1.9

[1] Plots drained for ca. 36 h and flooded after 5, 14 and 22 days posttreatment.

Table 4. Efficacy of sustained release Altosid sand granules (1.3% AI S-methoprene) at 3 application rates to control adult *Culex quinquefasciatus* emergence in freshwater plots.

Days post-treatment	Application rate (kg/ha)	No. pupae sampled	Percent emergence inhibition ± SE
8	11.2	189	94.8 ± 5.8
	16.8	208	99.5 ± 0.7
	22.4	110	100.0 ± 0.0
	Control	200	0.0 ± 0.0
16	11.2	201	100.0 ± 0.0
	16.8	192	95.2 ± 6.1
	22.4	202	100.0 ± 0.0
	Control	209	3.8 ± 5.3
22	11.2	202	69.4 ± 8.4
	16.8	207	93.7 ± 3.3
	22.4	197	94.8 ± 4.3
	Control	211	3.4 ± 1.9
28	11.2	206	88.1 ± 3.3
	16.8	195	77.6 ± 6.4
	22.4	197	93.5 ± 7.2
	Control	204	6.3 ± 1.9
37	11.2	211	7.7 ± 1.8
	16.8	217	49.3 ± 15.0
	22.4	208	98.0 ± 1.4
	Control	206	1.0 ± 1.3
42	11.2	207	19.9 ± 7.3
	16.8	210	34.7 ± 9.9
	22.4	211	79.3 ± 7.9
	Control	207	2.4 ± 0.7
51	11.2	204	24.7 ± 8.3
	16.8	200	38.9 ± 21.1
	22.4	206	72.6 ± 5.2
	Control	201	3.5 ± 2.1

control emergence was comparable to that of sand granules applied at 16.8 kg/ha on the same day of flooding. At 22 days after flooding, the pellets and granules gave 92.4% and 93.7% inhibition, respectively.

Rainfall during the 3rd study was 27.1 cm, and the water temperature ranged from 26 to 34°C ($\bar{x}$ = 30°C). The air temperature ranged from 20 to 38°C ($\bar{x}$ = 29°C). The water pH recorded at the start of the test and when pupae were sampled ranged from 6.6 to 7.6 ($\bar{x}$ = 7.1).

CONCLUSIONS

Study 1 demonstrated that a sustained release formulation of Altosid sand granules (1.3% AI S-methoprene) applied 7 days preflood at an application of 5.6 kg/ha rate effectively controlled adult *Ae. taeniorhynchus* emergence in saltwater plots for 44 days posttreatment. In the saltwater plots treated with Altosid pellets, 100% emergence inhibition was achieved. However, in concurrent freshwater tests against *Cx. quinquefasciatus*, the sand granules applied at 5.6 kg/ha were not effective. No emergence inhibition greater than 39% was recorded, but the pellets controlled emergence for 29 days posttreatment.

The 100% emergence inhibition recorded in all the treatment plots in the 2nd study indicated there was no apparent degradation of either the Altosid sand granules or pellets in the semi-permanent saltwater test. Altosid sand granules or pellets applied at a rate of 5.6 kg/ha provided effective emergence inhibition of *Ae. taeniorhynchus* adult mosquitoes for 30 days posttreatment in the semi-permanent habitat.

In the 3rd study, the Altosid sand granules applied at 22.4 kg/ha were effective in controlling 98% of the adult *Cx. quinquefasciatus* emergence for 37 days posttreatment. The 16.8 kg/ha rate controlled emergence (93%) for 22 days posttreatment, but acceptible emergence inhibition at the 11.2 kg/ha rate lasted for only 16 days posttreatment. At 22 days posttreatment, 69% emergence inhibition was recorded in plots treated at the 11.2 kg/ha rate. Effectiveness of the 16.8 kg/ha granule application rate 22 days posttreatment compared favorably with the pellets' 5.6 kg/ha rate in the freshwater test in the first study.

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