Field evaluation of an insect growth regulator, pyriproxyfen, against *Aedes togoi* larvae in brackish water in South Korea

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ABSTRACT: The granular formulation of 0.5% pyriproxyfen was evaluated for inhibition of emergence of *Aedes togoi* in brackish water of rock pools near a coastal area in Pusan, South Korea. Complete adult emergence inhibition in 4th-stage larval and pupal isolations was affected from 5-40 days at 0.05 mg/l after treatment. Most inhibition rates were over 80% throughout the test period at all test concentrations of pyriproxyfen except 61.0% and 67.5% of inhibition rates at 0.01 mg/l at 52 days and 62 days after treatment, respectively. It is suggested that the dose for successive control of *Ae. togoi* for long-term might be 0.05-0.1 mg/l of 0.5% pyriproxyfen granules.***Journal of Vector Ecology* 26(1): 39-42. 2001.**

Keyword Index: insect growth regulator, pyriproxyfen, *Aedes togoi*, mosquito control, brackish water

INTRODUCTION

Aedes togoi (Theobald) is recognized as the dominant pest mosquito in the coastal areas and as the main vector of malayi filariasis in South Korea. Rock pools with brackish water near the coast and inland fresh water containers are the main larval breeding sites. The primary reason for this distinction of being a pest and a vector is that this mosquito feeds both diurnally and nocturnally, whereas, other species found in the area are only nocturnal feeders. Control measures against *Ae. togoi* as well as other species in Korea are primarily with adulticides. *Anopheles sinensis* Wiedemann and *Culex tritaeniorhynchus* Giles, vectors of malaria and Japanese encephalitis, respectively, became resistant to organophosphorus insecticides by repeated applications (Shim et al. 1995a, b). Because the mosquitoes in South Korea are currently being controlled using only adulticides with thermal fogging, an effective and high level of control is not achievable.

Insect growth regulators (IGRs) affect the hormonal control of mosquito growth and development. The main effect of IGRs is the inhibition of adult emergence, but reproduction and ecdysteroid production in surviving females are also affected (Fournet et al. 1993, 1995). In general, IGRs have high levels of activity and efficacy against various species of mosquitoes in a variety of habitats (Mulla et al. 1989). Additionally, it has been known that they have shown a good margin of safety to non-target biota including fish and birds. Residue and non-target studies indicated that IGRs have no prolonged residues and are an environmentally safe compound with minimal impact on non-target organisms (Miura and Takahashi 1973, 1975; Mulla et al. 1985, 1986). On the basis of these attributes, IGRs are likely to provide additional tools for mosquito control, supplementing microbial larvicides, pyrethroids and organophosphorus larvicides (Mulla et al. 1989). It appears that IGRs are suitable candidate larvicides for mosquito control due to their greater margin of safety for non-target biota and operational properties.

Pyriproxyfen is an IGR and affects the physiology of morphogenesis, reproduction and embryogenesis of insects (Kawada et al. 1988). This IGR exhibits a high level of activity against *Culex, Aedes, Psorophora* and *Anopheles* mosquitoes (Mulla et al., 1986, 1989; Kawada et al., 1988; Schaefer et al., 1988; Suzuki et al., 1989; Kerdpibule, 1989; Mulligan et al., 1990; Ishii et al., 1990; Kamimura and Arakawa, 1991). Kamimura and Arakawa (1991) reported that pyriproxyfen was extremely effective against larvae of *Cx. pipiens pallens* and *Cx. tritaeniorhynchus* which showed high resistance to organophosphorus insecticides. Complete inhibition of adult emergence continued for 3 weeks or more in open containers and irrigation ditches at a concentration of 0.01 ppm, in cesspools at 0.05 ppm and in sewers with inflow of house wastewater at 0.1 ppm (AI). The present study was conducted to evaluate pyriproxyfen against *Ae. togoi* in brackish water.

MATERIALS AND METHODS

Pyriproxyfen (Sumilarv, 0.5% granular formulation; Sumitomo Chem. Co., Osaka, Japan) was evaluated against *Ae. togoi* larvae in brackish water in 10 rock pools (avg. 2.0 x 1.1 m by 0.3 m deep) near a coastal area in Pusan city from August through October, 1999 (Table 1). In these rock pools, water was relatively stable during the study.

The granular formulation was evenly distributed over each site by hand in August, 1999. The formulation was tested at 4 treatment rates (0.01, 0.05, 0.1 and 0.5 mg/l A.I.) with 1-4 sites for each treatment. Two sites were left untreated as controls. Mosquito samples per site were taken prior to treatment and once every week after treatment. For two months, an average of 35, 4th-instar larvae and pupae in the field water were collected from each site using an aquatic net at each evaluation time. Water samples containing the larvae and pupae were placed from the water surface without the granules in plastic bottles using a dipper and transported back to a laboratory in styrofoam chests. To reduce mosquito activity and minimize physical damage and mortality during transportation, the chest was chilled with a small amount of wet ice enclosed in a plastic bag. In the laboratory, 150 ml of brackish water from each treated and control site were transferred into 250 ml beakers (in triplicates) and wild larvae and pupae from each treatment were placed separately in each beaker in their respective water using pipettes. Test organisms were placed in two incubators where temperatures were maintained at 27°C. Mortality readings were taken daily and percent inhibition of adult emergence (% EI) was determined. Percentage data based upon mortality in each site were corrected against control sites using Abbott's formula (Abbott 1925), arcsine transformed, and subjected to ANOVA. Means calculated for the treatments of 0.1 and 0.5 mg/l were separated using a student *t*-test. Air temperatures and precipitation were checked using the data from the Central Meteorological Office during the test period from August 16 through November 4, 1999 to analyze with test results.

RESULTS AND DISCUSSION

Average air temperatures were 21.4 - 26.9°C (mean 24.3°C) from August 16 to 31, 1999; 19.3 - 26.6°C (mean 22.4°C) from September 1 to 30; 10.9 - 23.2°C (mean 17.7°C) from October 1 to 31; and 9.7 - 11.9°C (mean 10.8°C) from November 1 to 4 during the test periods. It rained for a total of 34 days in the test period including August 18, 21, 22, 23, 24, 25, 26, 27, 29, 30 and 31 (total precipitation 373 mm); September 3, 5, 6, 7, 8, 10, 17, 18, 20, 21, 22, 23 and 24 (total precipitation 320 mm); and October 4, 7, 11, 12, 13, 14, 15, 16 and 31 (total precipitation 131 mm); and November 1 (precipitation 5 mm) (Table 2).

In the brackish water of the rock pools, the results are given as average % mortality every 10 days after treatment in Table 2. Adult emergence inhibition in larval and pupal isolations were over 90% for 40 days after treatment at all concentrations of pyriproxyfen except 0.01 mg/l. Excellent control (>95%) was achieved at all concentrations tested against larvae up to 9 days post-treatment and residual control remained above 61% against larvae for 70 days. The mosquito

Table 1. Characteristics and dosages of pyriproxyfen treatment of 10 rock poolsa djacent to coastal area with brackish water and naturally bred *Aedes togoi* larvae and pupae, 1999.

Rock Pool No.	Conc. (mg/l)	Site Measurements (m) Length	Width	Water Depth	Water Volume (ton)	Water Salinity (%)
1	0.10	1.2	2.0	0.2	0.48	0.36
2	0.10	2.2	1.9	0.2	0.84	0.03
3	0.10	2.1	0.7	0.2	0.29	0.04
4	0.10	2.0	1.5	0.4	1.20	0.05
5	0.50	1.3	0.6	0.2	0.16	0.05
6	0.50	2.6	0.4	0.2	0.21	0.14
7	0.05	2.5	1.1	0.4	1.10	1.04
8	0.01	1.4	0.6	0.2	0.17	0.61
9	0.00	2.0	1.0	0.3	0.60	0.80
10	0.00	2.4	0.7	0.3	0.50	0.16

Table 2. Average % mortality of *Aedes togoi* in brackish rock pools with controlled release formulation of pyriproxyfen (0.5% granules) and precipitation.

Post-treatment (d)	Concentration (mg/l)					
	0.01	0.05	0.1*	0.5*	Control	Precipitation (mm)
5- 9	96.3	100.0	100.0 (0.0)**	100.0 (0.0)	0.0 (0.0)	97.3
10-19	98.1	100.0	96.3 (7.4)	100.0 (0.0)	1.4 (1.9)	275.4
21-30	78.8	100.0	94.5 (7.8)	100.0 (0.0)	0.0 (0.0)	159.3
31-40	82.5	100.0	99.1 (1.9)	99.8 (0.3)	1.0 (1.3)	160.8
41-51	87.8	74.6	92.1 (15.9)	76.0 (29.6)	0.0 (0.0)	1.2
52-61	67.5	100.0	92.3 (14.5)	72.9 (18.1)	1.2 (1.7)	112.9
62-70	61.0	100.0	92.3 (15.4)	83.5 (10.5)	0.0 (0.0)	0.0

*Means between 0.1 and 0.5 mg/l in the same row are not significantly different ($P > 0.05$) by Student's *t*-test.
**Numbers in parenthesis represent one standard deviation.

breeding sites held brackish water (0.03%-1.04% salinity) and were exposed to heavy rainfall during the test period. Nevertheless, most inhibition rates were over 80% throughout the test period at all test concentrations of pyriproxyfen, except 61.0% and 67.5% of inhibition rates at 0.01 mg/l at 52 days and 62 days after treatment, respectively. The recorded results showed continuously high inhibition rates of over 80% for 70 days after treatment although comparatively lower inhibition rates (61.0%-76.0%) appeared at concentration of 0.01 mg/l after 41 days. Therefore, the residual activity of 0.5% pyriproxyfen granules inhibits emergence from pupae to adults of *Ae. togoi* in brackish water. It is suggested that the concentration for effective control of *Ae. togoi* in brackish water for long term is 0.05-0.1 mg/l (A.I.) using 0.5% pyriproxyfen granules.

In the field test, mosquito larvae and/or pupae were not found in five of the sites on some occasions. It might have been caused by extremely low or no population of mosquitoes due to high salinity from intake of sea water. Although mortality of larvae was not tabulated, the following observations were made concerning the period of activity. Little activity was observed against 4th-instar larvae and emerging adults. The formulation caused a high mortality during the pupal stage. The tendency of the inhibition of emergence in larval isolates in the present field test was the same as other previous studies. Just as in previous works (Mulligan and Schaefer, 1990; Kamimura and Arakawa, 1991), emergence inhibition rates were higher in pupal isolates than in larval isolates. Therefore, it is suggested that the actual mortality in the test sites might be higher than the results obtained in the larval isolates as well as pupal isolates. However, the effect decreased somewhat when the concentration was diluted by rainwater (Table 2). Pyriproxyfen granules may be of benefit to control mosquitoes in floodwater situations because the concentration of this material has been predicted to be higher in the bottom water than the upper water for a long period of time when they were applied as indicated by Kamimura and Arakawa (1991). However, the emulsion formulation did not remain in the bottom mud for a long period (Schaefer et al., 1988). Kamimura and Arakawa (1991) agreed with Syafruddin et al. (1990) that granules of this IGR sink to the bottom, and the effective component was slowly released; thus, the effective component remained in the substratum for a substantial time, being slowly released in the water.

In conclusion, 0.5% pyriproxyfen granules provided the greatest initial and residual activities against *Ae. togoi* larvae in rock pools with brackish water and it effectively inhibited adult emergence of *Ae. togoi* for more than 2 months at a concentration of 0.05 mg/l or higher. There is sufficient evidence to support that pyriproxyfen may offer excellent potential for *Ae. togoi* control with long residual activity in mosquito breeding sites even in brackish water. This preliminary study has identified a promising chemical such as pyriproxyfen that may be considered in the development of an integrated approach to population management of various species of mosquitoes including *Ae. togoi,* which is a dominant species in coastal areas of Northeast Asia.

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