1997

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The Florida Entomologist, Vol. 80, No. 1 (Mar., 1997), pp. 84-91
Published by Florida Entomological Society

CONTROL OF *SOLENOPSIS INVICTA* (HYMENOPTERA:FORMICIDAE) WITH TEFLUBENZURON

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ABSTRACT

Teflubenzuron baits were active against laboratory colonies of the red imported fire ant, *Solenopsis invicta* Buren. Worker brood production ceased soon after treatment and by four weeks posttreatment, most colonies were devoid of brood. Worker ants did not exhibit any direct effects from treatment with teflubenzuron. As is typical with most insect growth regulators, colony mortality was slow and dependent on old-age attrition of the worker ants. A few (<25) female alates were produced in one of the laboratory colonies at 12 weeks posttreatment.

The teflubenzuron baits reduced field colonies of *S. invicta* by 75-79% within 6 weeks after treatment, 83-86% within 13 weeks, and 77-91% within 17 weeks. At 17 weeks posttreatment, the presence of worker brood in the plots treated with the lower rates, 0.1125% and 0.0225%, gave evidence of recovery of some colonies. However, the results of the field tests indicate that teflubenzuron has excellent potential for control of field populations of *S. invicta*.

RESUMEN

Los cebos de teflubenzuron fueron activos contra colonias de laboratorio de la hormiga roja importada de fuego, *Solenopsis invicta* Buren. La producción de obreras cesó en breve tiempo después del tratamiento, y a las 4 semanas la mayoría de las colonias quedó desprovista de ellas. Las obreras no mostraron efectos directos del tratamiento con teflubenzuron. Como es típico en la mayoría de los regluadores del crecimiento de insectos, la mortalidad de la colonia fue lenta y dependiente del desgaste por edad de las obreras. Unas pocas (<25) hembras aladas fueron producidas en las colonias de laboratorio a las 12 semanas del tratamiento. Los cebos de teflubenzuron redujeron las colonias de campo de *S. invicta* en un 75-79% en 6 semanas, en un 83-86% en 13 semanas, y en un 77-91% en 17 semanas después del tratamiento. A las 17 semanas del tratamiento, la presencia de obreras inmaduras en las parcelas tratadas con las dosis más bajas, 0.1125% y 0.0225%, fue una evidencia de la recuperación de algunas colonias. Sin embargo, los resultados de pruebas de campo indicaron que teflubenzuron tiene un excelente potencial para el control de poblaciones de campo de *S. invicta*.

Insect growth regulators (IGRs) are highly active against the red imported fire ant, *Solenopsis invicta* Buren, (Banks 1986, Banks et al. 1978, 1983, 1988, Phillips et al. 1985, 1989, Vinson & Robeau 1974, Vinson et al. 1974). The most effective IGRs prevent the replacement of the worker caste in colonies through mortality of developing immatures, degeneration of the reproductive organs of the queen, and/or a shift in caste differentiation from worker to sexual forms. This lack of worker replacement usually results in colony death because the existing worker ants die and dependent castes and immatures succumb from neglect. Juvenile hormone mimics have been the most effective IGRs, and two of these materials, fenoxycarb and 1-(8-methoxy-4,8-dimethylnonyl)-4-(1-methylethyl) benzene, have been used in commercial baits for fire ant control.

Another group of IGRs, i.e. Benzoylphenyl urea (BPU) compounds, of which diflubenzuron (dimilin) is the best known, has been successfully developed as control agents for a number of other insects. These chemicals are commonly known as chitin inhibitors because they interfere with normal endocuticular deposition and molting in insects. They also are ovicidal in some cases. Because of the low solubility of the BPUs in soybean oil or other food attractants, this group of IGRs has not been used successfully against fire ants. A newer BPU, teflubenzuron [1-(3,5-dichloro-2,4-difluorophenyl)-3-(2,6-difluorobenzoyl)-urea] (American Cyanamid Co., Wayne, NJ 07470 USA), is much more soluble in food attractants and may offer promise in fire ant management systems. Teflubenzuron is considerably more physiologically active than diflubenzuron against a number of agricultural pests and has effectively controlled some insects, such as the diamondback moth, *Plutella xylostella* (Linnaeus), and the red flour beetle, *Tribolium castaneum* (Herbst), that are highly resistant to other types of insecticides (Ishaaya & Klein 1990). Herein, we report the results of laboratory and field studies with teflubenzuron against *S. invicta*.

MATERIALS AND METHODS

Laboratory Tests

Three laboratory tests were conducted with laboratory-reared queenright *S. invicta* colonies (Banks et al. 1981). For each test, teflubenzuron (10% emulsifiable concentrate) was combined with once-refined soybean oil to produce baits containing 0.1% and 0.5% active ingredient (wt/wt). In each test, three colonies were exposed to 0.5 ml of each bait concentration. The 0.1% solution (0.5 mg per colony AI) and the 0.5% solution (2.5 mg per colony AI) were tested against colonies with 20-25 ml brood and 20,000-40,000 workers, and 30-35 ml brood and 50,000-70,000 workers, respectively. Three colonies were exposed to 0.5 ml of neat once-refined soybean oil and served as non-treated controls. The test colonies were allowed ad libitum feeding on the oil solutions which were offered in micropipets. The colonies were returned to normal diet (Banks et al. 1981) 24 h after treatment and maintained in the laboratory at 27 ± 2°C. Monthly observations (including numbers of workers, reproductives, and amount of brood) were made until the colonies died, returned to their normal pretreatment index level, or for one year, whichever occurred first.

Effectiveness of the treatments was based on comparison of the before and after treatment size index of each colony. This index was derived by multiplying the assigned values for worker numbers, i.e. 1-6, by the quantity of worker brood, i.e. 1-25, (Table 1); e.g. a colony with a rating of 5F would have a colony index of 125 (5 × 25) (Banks & Lofgren, 1991). For each of the three tests, data were combined for the three colonies. Mean percent reduction in colony indices were analyzed using an analysis of variance and Tukey's Studentized Range (HSD) test (SAS Institute 1988).

Field Tests

Pregel defatted corn grit baits containing 0.01125, 0.0225, or 0.045% teflubenzuron were prepared in our laboratory for the field tests as follows. Technical teflubenzuron (97.5%) was dissolved in dimethyl formamide (0.5-1.5% by weight of oil in the formulation) and the solution was incorporated into warm (20-25°C) once-refined soybean oil. The oil solution was slowly poured over the corn grits as they were stirred in a large food mixer. Stirring continued for about 10 minutes to insure thorough mixing of the oil and grits.

TABLE 1. VALUES FOR CALCULATION OF COLONY INDEX OF LABORATORY COLONIES OF *S. INVICTA*.

Estimated Number of Worker Ants			Estimated Quantity of Worker Brood (gms)		
	Rating	Value		Rating	Value
<100	1	1	0	A	1
101-5000	2	2	1-5	B	5
5001-20000	3	3	5-10	C	10
20001-35000	4	4	10-20	D	15
35001-50000	5	5	20-30	E	20
>50000	6	6	>30	F	25

Each bait was broadcast with a tractor-mounted granular applicator (Williams et al. 1983) at a rate of 1.12 kg/ha on 0.2-ha plots with an average of 12 mounds per hectare in nongrazed permanent pasture in Union County, Florida. Three plots were treated with each teflubenzuron concentration; three plots were treated with Logic (fenoxycarb, Ciba-Geigy, Greensboro, NC) at a rate of 1.12 kg/ha as a standard, and three plots were left untreated as a control. Efficacy of the treatments was evaluated by comparison of the before and after (6, 13 and 17 weeks) treatment population indices using standard methods established for determination of population indices of *S. invicta* (Banks et al. 1988). Mean reductions in population indices were analyzed using an analysis of variance and Tukey's Studentized Range (HSD) test (SAS Institute 1988).

Results and Discussion

Laboratory tests

Teflubenzuron was very active against laboratory colonies of *S. invicta* (Table 2). In test one, worker brood production ceased soon after treatment and by four weeks posttreatment two colonies at the 0.5 mg dosage were devoid of brood and only a few pupae remained in the third colony. All colonies at the 2.5 mg rate were devoid of brood at four weeks. The only worker brood production thereafter through the one-year test occurred in one colony at the 0.5 mg rate; about 0.5 ml was present at the one-year posttreatment evaluation. In test one, all three colonies subjected to the 2.5 mg rate died by 36 weeks; however, two colonies at the 0.5 mg rate were alive at one year, although neither contained more than 500 workers and only one colony had a queen present. It is doubtful that these colonies would have survived under field conditions.

Colony reduction did not occur as quickly in the second test. All three colonies treated at 0.5 mg and two treated at 2.5 mg still contained some worker brood at four weeks; however, all treated colonies were devoid of worker brood by eight weeks and remained so until the test was discontinued after 32 weeks. At the conclusion of test two, fewer than 500 workers remained alive in any treated colony.

In test three, with the exception of one 0.5 mg treatment, all colonies at both dosages (0.5 mg and 2.5 mg) were devoid of worker brood by sixteen weeks and remained so until the test was discontinued after 32 weeks. The one colony at 0.5 mg still had worker brood present until the end of the test. At the end of test three, fewer than 100 workers remained alive in any treated colony with all colonies having fewer than 25 workers, including one colony at 0.5 mg that contained a small amount of brood. All of the queens in the treated colonies were dead or were not producing eggs except one colony treated with 0.5 mg.

Worker ants did not exhibit any direct effect of treatment with teflubenzuron in any test. Thus, as is typical with most insect growth regulators, colony mortality was slow and dependent on old-age attrition of the worker ants. No alate production occurred in any of the treated colonies in test one and test three; however, in test two, a few (<25) female alates were produced at 12 weeks posttreatment in two replicates at the 2.5 mg rate.

The untreated colonies in test one showed no change or increase in size through 24 weeks posttreatment, but began a decline thereafter that left all three devoid of worker brood and reduced in size by one year. The controls in test two began a decline at 12 weeks that resulted in termination of the test after 32 weeks. The control colonies in test three were significantly different than the treatments until week 16. After this time, although they were noticeably different containing large physogastric

TABLE 2. EFFECTIVENESS OF TEFLUBENZURON AGAINST LABORATORY COLONIES OF *S. INVICTA*.

Dosage (mg/Colony)	Pretreatment Colony Index	% Reduction in Colony Index after Week[1]						
		4	8	12	16	20	24	32
				Test 1				
0.5	101.7a	92.8a	97.0a	97.3a	97.9a	97.9a	98.2a	98.2a
2.5	150.0a	90.7a	96.7a	97.3a	98.2a	98.5a	98.7a	98.9a
CK	131.7a	-8.3b	-1.7b	-15.0b	-15.0b	-15.0b	-15.0b	25.0a
				Test 2				
0.5	133.3a	83.8a	97.2a	98.0a	98.3a	98.5a	98.5a	—[2]
2.5	150.0a	87.5a	96.5a	98.0a	98.0a	98.2a	98.5a	—
CK	140.0a	-8.3b	-8.3b	29.2a	23.9a	23.9a	23.9a	—
				Test 3				
0.5	142.0a	82.2a	97.2a	97.9a	98.1a	98.1a	98.6a	96.9a
2.5	132.0a	95.9a	96.9a	97.2a	97.5a	97.7a	98.2a	95.8a
CK	140.0a	5.6b	5.6b	-8.3b	23.7a	23.7a	24.3a	25.0a

[1]Means within columns followed by the same letter are not significantly different ($P < 0.05$), N = 3 using Tukey's HSD test on arcsine transformed data.
[2]Observations were made at 32 wks but data were not included because of high check mortality.

TABLE 3. EFFECTIVENESS OF TEFLUBENZURON BAITS AGAINST FIELD POPULATIONS OF *S. INVICTA*.

	Application rate		Pretreatment		% Reduction in Population Index after Indicated Weeks[1]		
Bait	Bait (kg/ha)	AI (g/ha)	No. mounds	Pop'n index	6	13	17
Teflubenzuron 0.01125%	1.12	0.051	37	788	78.3a	83.4a	77.5a
Teflubenzuron 0.0225%	1.12	0.102	37	877	75.5a	84.3a	80.6a
Teflubenzuron 0.045%	1.12	0.204	36	809	79.0a	86.2a	91.3a
Logic (standard) 1.0%	1.12	4.53	39	866	81.8a	92.4a	97.9a
Control	—	—	29	675	-17.0b	11.1b	14.7b

[1]Means within columns followed by the same letter are not significantly different ($P < 0.05$), N = 3 using Tukey's HSD test on arcsine transformed data.

queens, large amounts of brood, and numerous workers, the colony indices were not statistically different.

Significant ($P < 0.05$) reductions in colony indices of treated colonies compared with untreated controls were observed from 4-24 weeks in test one, up to 8 weeks in test two and from 4-12 weeks in test three. These results indicated that the reductions were caused by teflubenzuron and not attributable to a decline observed in the untreated controls late in the tests. The decline in the control colonies is not readily explainable; however, they might have been inadvertently exposed to teflubenzuron over the long test period. Food and water tubes for all of the colonies, both treated and controls, were handled using the same gloves and forceps. This technique has not appeared to affect control colonies in other tests with chemicals. However, teflubenzuron is biologically effective at extremely low dosages and they may have been exposed to minute residues in these tests.

Field tests

The teflubenzuron baits reduced the population indices of field colonies of *S. invicta* by 75-79% within 6 weeks after treatment (Table 3). No significant difference was noted in the effectiveness of any of the teflubenzuron baits or the Logic standard at either the 6 or 13 week evaluation. By 17 weeks, however, the presence of worker brood in 6 and 5 colonies, respectively, in plots treated with the 0.01125% and 0.0225% baits gave some evidence of recovery. No surviving colonies in plots treated with the 0.045% teflubenzuron or Logic baits contained any worker brood after 17 weeks. The number of workers in the surviving colonies after 17 weeks had been substantially reduced at the highest dosage of teflubenzuron with 82.1% of the colonies having <10,000 workers, 48.1% having <1,000 which was not statistically different than Logic standard (100% of the colonies had <10,000 workers, 91.7% had <1,000 workers).

The results of the field tests indicate that teflubenzuron has excellent potential for control of field populations of *S. invicta*. The levels of teflubenzuron tested in the field were extremely low when compared with Logic; therefore, higher levels of teflubenzuron may produce even better control.

ACKNOWLEDGMENTS

We thank Karen Vail for her laboratory and statistical assistance and J. Hogsette, B. Forschler, and D. Oi for their comments on the manuscript. The second and third authors are retired from the USDA.

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