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RESISTANCE TO TWO CLASSES OF INSECTICIDES IN SOUTHERN CHINCH BUGS (HEMIPTERA: LYGAEIDAE)

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ABSTRACT

Southern chinch bugs were tested from 10 locations in Florida to determine possible resistance to 4 insecticides. Resistance of varying degrees was found in all 4 insecticides: bifenthrin, deltamethrin, imidacloprid, and lambda-cyhalothrin. This study is the first to show southern chinch bug resistance to the latter 3 insecticides. Our data also show that multiple locations are necessary for insecticidal testing for southern chinch bugs since results from 1 location can be very misleading.

Key Words: chinch bugs, insecticide resistance, St. Augustinegrass

RESUMEN

Los chinches vellosos en 10 sitios del estado de la Florida fueron evaluados para determinar su posible resistencia a 4 insecticidas. Se encontró diferentes grados de resistencia en los 4 insecticidas estudiadas: bifenthrin, deltamethrin, imidacloprid y lambda-cyhalothrin. Este es el primer estudio que muestra la resistencia del chinche velloso en los 3 insecticidas últimos. Nuestros datos también indican que se necesitan varias localidades para probar los insecticidas usados contra el chinche velloso dado que los resultos de un solo sitio pueden darnos una falsa guia.

St. Augustinegrass, *Stenotaphrum secundatum* (Walt.) Kuntze, lawns are used throughout the southern United States for their climatic adaptation and their ability to tolerate full sun to moderate shade. The southern chinch bug, *Blissus insularis* Barber, is the plant's most damaging pest (Crocker 1993). The adaptability of this insect is shown by developing resistance to insecticides (Reinert & Portier 1983; Cherry & Nagata 2005) and overcoming host plant resistance (Busey & Center 1987; Cherry & Nagata 1997).

Insecticide resistance in southern chinch bugs (SCB) was first noted in 1953 in Miami where Wolfenbarger (1953) showed poor control with chlordane. By 1958, Kerr and Robinson (1958) documented resistance to DDT at Sarasota, Florida. The chinch bugs had become resistant to parathion at Fort Lauderdale, Florida by 1960 (Kerr 1960). Chinch bug resistance to both chlorpyrifos and diazinon was confirmed in 1977 at Pompano Beach, Florida (Reinert & Niemczyk 1982). And, in 1983, Reinert & Portier (1983) reported a 9.2-fold level of resistance to the carbamate insecticide, propoxur by SCB. Hence, by 1983, SCB had shown resistance to chlorinated hydrocarbon, organophosphate, and carbamate insecticides.

In recent years, synthetic pyrethroid insecticides have become increasingly used for SCB control in Florida. Bifenthrin is a synthetic pyrethroid compound used as a contact and stomach poison insecticide/acaricide (Thomson 1998). Bifenthrin has been and still is being used for SCB control in Florida. During 2003, reports of difficulty in controlling SCB with bifenthrin in Florida came to our attention. Cherry & Nagata (2005) were the first to show SCB resistance to bifenthrin. The objective of this study was to determine if SCB has developed resistance to other synthetic pyrethroids and/or imidacloprid, a neonicotinoid insecticide in a different chemical class.

MATERIALS AND METHODS

Chinch bugs were collected by vacuuming in infested St. Augustinegrass lawns. Southern chinch bugs have been shown to have localized responses to insecticides (Reinert & Portier 1983; Cherry & Nagata 2005). Hence, all SCB were obtained only from a specific lawn at each location. After collection, the insects were stored at 18°C in buckets with St. Augustinegrass until used for testing. The insects were collected from 10 different urban areas in 5 counties in central and southern Florida. Chinch bugs were not collected from northern Florida since fewer chinch bugs are found there and control difficulties there were not brought to our attention. Three of the populations came from locations where there was difficulty in controlling chinch bugs and insecticidal resistance was suspected. For comparison, 7 populations were selected randomly as encountered in other areas with no knowledge of the insecticidal use history of the location or efficacy of insecticides against the insects.

Methods for testing closely approximated the methods Reinert & Porter (1983) and Cherry & Nagata (2005) used earlier in toxicological tests against SCB. The 4 insecticides selected for testing were bifenthrin, deltamethrin, lambda-cyhalothrin, and imidacloprid. The first 3 insecticides are synthetic pyrethroids labeled for SCB control in Florida. Imidacloprid is a neonicotinoid insecticide labeled for suppression of southern chinch bugs in Florida lawns. In the laboratory, serial dilutions were made from commercial formulations of the 4 insecticides. Freshly harvested St. Augustinegrass stolons (ca 10 cm long) were dipped into dilutions and allowed to air dry. Stolons were placed individually into Petri dishes (15 cm diam.) containing moist filter paper to maintain high humidity.

Preliminary tests showed that very high doses of deltamethrin and lambda-cyhalothrin were necessary to kill SCB in 24 h. Hence, 20 adult SCB were placed into each Petri dish and held 24 h for bifenthrin and imidacloprid and 72 h for deltamethrin and lambda-cyhalothrin at 28°C and 14 D/10 L. For each test, 5 to 7 concentrations with a control were tested. Robertson et al. (1984) noted that a sample size of 120 appears to be the minimum necessary for reliable LC_{50} estimation. Our sample sizes of adults tested ranged from 120 to 360 for each insecticide at each location to estimate LC_{50} for that location. Different numbers of adults tested per insecticide depended on availability of adults. Since our own objective was to estimate LC_{50} values, we selected doses expected to give 25 to 75% mortality for best LC_{50} estimation as suggested by Robertson et al. (1984). Mortality is defined as virtually no movement by an adult during a 5 min observation period through a 5× large magnifying lens. The no movement criterion was used to avoid ambiguities of comatose, unable to stand, moribund, etc. In a separate test, 98% of adults we classified as dead after insecticide exposure did not regain movement after 24 h and the 2% showed only small twitches. Hence we believe the no movement criterion was a good measure of mortality since adults classified as dead still appeared dead 24 h later.

Because of the longer 72 h testing period, all results were corrected for control mortality by Abbott's formula (Abbott 1925). Lethal median concentrations (LC_{50}) and slopes were calculated for each population by using probit analysis on Log_{10} dose (SAS 2006). Resistance ratios were determined for each insecticide at each location to compare ratios. The resistance ratio is defined as the LC_{50} of the insecticide at that location divided by the lowest LC_{50} of the insecticide at any location.

RESULTS AND DISCUSSION

Toxicological data for the 10 chinch bug locations are shown in Tables 1 to 4. Lowery & Smirle (2003) note that non-overlapping 95% confidence intervals show that LC_{50} values are significantly different ($P < 0.05$). A wide range of LC_{50} values were observed in the 10 locations with many of the LC_{50} values within insecticides being significantly different.

In bifenthrin tests (Table 1), 6 of the 10 locations had LC_{50} values significantly higher than the lowest LC_{50}. These data show SCB resistance to bifenthrin as previously reported by Cherry & Nagata (2005). Chinch bugs at all 3 of the locations with control difficulties showed some resistance to bifenthrin. In contrast, only 3 of the 7 randomly chosen locations showed any level of SCB resistance to bifenthrin. Also, the mean LC_{50}

TABLE 1. LETHAL CONCENTRATIONS OF BIFENTHRIN TO SOUTHERN CHINCH BUGS AT DIFFERENT LOCATIONS IN FLORIDA.

Location	LC_{50}[a]	CL[b]	Slope ± SE	*n*[c]
Control difficulty				
Clermont	102[d]	40-218	0.8 ± 0.2	240
Lady Lake	18[d]	5-35	1.1 ± 0.2	120
Palm Coast	59[d]	24-111	1.0 ± 0.2	120
Random				
Belle Glade	7	2-17	0.8 ± 0.2	240
Fort Pierce	19	0-54	1.2 ± 0.4	120
Gainesville	8	0-45	1.0 ± 0.4	120
Port St. Lucie	1	0-2	0.4 ± 0.2	120
Royal Palm Beach	65[d]	18-147	0.8 ± 0.2	120
Wellington	12[d]	5-20	1.8 ± 0.5	120
West Palm Beach	6[d]	4-7	2.7 ± 0.6	240

[a]ppm of AI.
[b]95% confidence limits.
[c]Number tested.
[d]Significantly different ($P < 0.05$) from lowest LC_{50} obtained for insecticide.

TABLE 2. LETHAL CONCENTRATIONS OF DELTAMETHRIN TO SOUTHERN CHINCH BUGS AT DIFFERENT LOCATIONS IN FLORIDA.

Location	LC_{50}[a]	CL[b]	Slope ± SE	*n*[c]
Control difficulty				
Clermont	171[d]	95-297	1.2 ± 0.2	120
Lady Lake	634[d]	240-7264	0.6 ± 0.2	120
Palm Coast	40[d]	13-80	1.0 ± 0.2	120
Random				
Belle Glade	6	3-11	1.1 ± 0.2	120
Fort Pierce	8	0-38	0.4 ± 0.1	360
Gainesville	1	0-8	0.6 ± 0.3	120
Port St. Lucie	3	0-10	0.8 ± 0.3	360
Royal Palm Beach	46[d]	16-147	0.5 ± 0.1	240
Wellington	3	0-23	0.3 ± 0.1	240
West Palm Beach	859[d]	333-11275	2.7 ± 0.2	120

[a]ppm of AI.
[b]95% confidence limits.
[c]Number tested.
[d]Significantly different ($P < 0.05$) from lowest LC_{50} obtained for insecticide.

from the locations with control difficulties was 59.7 ppm versus 16.9 ppm from random locations. These data are consistent with Cherry & Nagata (2005) who reported that most SCB populations in Florida are still susceptible to bifenthrin.

In deltamethrin tests (Table 2), 5 of the 10 locations had LC_{50} values significantly higher than the lowest LC_{50}. These data show SCB resistance to deltamethrin which has not been reported previously. Chinch bugs at all 3 of the locations with control difficulties showed some resistance to deltamethrin. The Clermont, Lady Lake and West Palm Beach locations had very high LC_{50} values indicating high deltamethrin resistance at these locations.

In imidacloprid tests (Table 3), 3 of 10 locations had LC_{50} values significantly higher than the lowest LC_{50}. These data show SCB resistance to imidacloprid and this is the first report of SCB resistance to any neonicotinoid insecticide. However, the highest resistance ratio in imidacloprid was 37.2 versus 102 for bifenthrin and 859 for deltamethrin. These latter data show that there was less variability to SCB response to imidacloprid than the more widely fluctuating LC_{50} values seen in bifenthrin and especially deltamethrin.

In lambda-cyhalothrin tests (Table 4), 1 of the 9 locations had a LC_{50} significantly higher than the lowest LC_{50}. These data show SCB resistance to lambda-cyhalothrin, which had not been re-

TABLE 3. LETHAL CONCENTRATIONS OF IMIDACLOPRID TO SOUTHERN CHINCH BUGS AT DIFFERENT LOCATIONS IN FLORIDA.

Location	LC_{50}[a]	CL[b]	Slope ± SE	*n*[c]
Control difficulty				
Clermont	121	40-279	1.0 ± 0.2	240
Lady Lake	44	1-126	0.8 ± 0.2	240
Palm Coast	180	17-465	0.6 ± 0.2	120
Random				
Belle Glade	65	11-228	0.6 ± 0.1	240
Fort Pierce	157	2-435	0.8 ± 0.3	240
Gainesville	385	47-1856	0.5 ± 0.2	120
Port St. Lucie	180	95-284	1.5 ± 0.3	120
Royal Palm Beach	1197[d]	492-7505	0.7 ± 0.2	120
Wellington	654[d]	415-1084	1.5 ± 0.3	120
West Palm Beach	1637[d]	834-6576	1.0 ± 0.3	120

[a]ppm of AI.
[b]95% confidence limits.
[c]Number tested.
[d]Significantly different ($P < 0.05$) from lowest LC_{50} obtained for insecticide.

TABLE 4. LETHAL CONCENTRATIONS OF LAMBDA-CYHALOTHRIN TO SOUTHERN CHINCH BUGS AT DIFFERENT LOCATIONS IN FLORIDA.

Location	LC_{50}[a]	CL[b]	Slope ± SE	*n*[c]
Control difficulty				
Clermont	NA[e]	—	—	—
Lady Lake	81[d]	39-166	1.6 ± 0.4	360
Palm Coast	27	2-73	0.7 ± 0.2	360
Random				
Belle Glade	6	0-20	1.0 ± 0.4	240
Fort Pierce	18	3-48	0.8 ± 0.2	240
Gainesville	4	0-16	0.8 ± 0.2	120
Port St. Lucie	7	0-22	0.7 ± 0.2	120
Royal Palm Beach	4	0-26	0.3 ± 0.1	240
Wellington	23	5-64	0.7 ± 0.2	240
West Palm Beach	27	11-51	0.6 ± 0.1	240

[a]ppm of AI.
[b]95% confidence limits.
[c]Number tested.
[d]Significantly different ($P < 0.05$) from lowest LC_{50} obtained for insecticide.
[e]NA = Not available due to insufficient number of insects.

ported previously. This one example of insecticide resistance did occur at Lady Lake, which was a location with control difficulties. Of the 4 insecticides, lambda-cyhalothrin had the lowest number of locations at which resistance was detected. Corroborating these data, it should be noted that the highest resistance ratio for lambda-cyhalothrin was 20.3, which was the lowest comparable ratio of the 4 insecticides.

As a last note, high variation in SCB response to insecticides at different locations has been found by Reinert & Portier (1983), Cherry & Nagata (2005) and in this study. These data show that multiple locations are necessary for insecticidal testing for SCB since results from 1 location can be very misleading.

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