Accepted for publication 21 September 2009. Published 23 November 2009.

St. Augustinegrass Cultivar Influences on Southern Chinch Bug and Predator Populations

Juang-Horng Chong, Department of Entomology, Soils, and Plant Sciences, Clemson University, Pee Dee Research and Education Center, 2200 Pocket Road, Florence, SC 29506; **S. Kristine Braman,** Department of Entomology, and **F. Clint Waltz,** Department of Crop and Soil Sciences, University of Georgia, Griffin Campus, 1109 Experiment Street, Griffin, GA 30223

Corresponding author: Juang-Horng Chong. juanghc@clemson.edu

Chong, J.-H., Braman, S. K., and Waltz, F. C. 2009. St. Augustinegrass cultivar influences on southern chinch bug and predator populations. Online. Applied Turfgrass Science doi:10.1094/ATS-2009-1123-01-RS.

Abstract

Field and greenhouse studies were conducted in Georgia and South Carolina to determine the tolerance and antibiosis effects of 15 St. Augustinegrass genotypes against the southern chinch bug. 'Floratam' and 'Floralawn' cultivars were highly resistant to southern chinch bug populations in Georgia and South Carolina. When southern chinch bugs were caged on Floratam for 37 days in a greenhouse study, both survivorship and adult reproduction were either stopped or significantly reduced. Color and quality ratings of heavily infested field plantings of 'Raleigh' were not significantly reduced even though this cultivar had the highest chinch bug density. Color and quality ratings for 'Amerishade' were significantly lower than all other cultivars. The data suggested that the St. Augustinegrass genotypes exhibited different levels of tolerance to infestation by southern chinch bug. The results called into question the established treatment threshold of 20 to 25 chinch bugs per 0.1 m², which does not consider the tolerance levels among St. Augustinegrass cultivars. Numbers of the predator *Lasiochilus palidulus* also varied by genotype and were least abundant in the resistant cultivars and most abundant in 'Winchester.'

Introduction

The southern chinch bug, *Blissus insularis* Barber (Hemiptera: Blissidae), is the most damaging insect pest of St. Augustinegrass, *Stenotaphrum secundatum* (Walt.) Kuntze, in the southeastern United States. Current management of the southern chinch bug relies heavily on the use of insecticides. The long-term dependency on insecticides has led to the development of resistance to carbamates (propoxur), organophosphates (chlorpyrifos, diazinon and parathion), cyclodiene organochlorines (chlordane), pyrethroids (bifenthrin, deltamethrin and lambda-cyhalothrin), DDT, and neonicotinoids (imidacloprid) in several southern chinch bug populations in Florida (5,6,9,10,19,20,23). St. Augustinegrass cultivars that offer resistance, such as Floratam, are attractive alternatives to consumers because of their reduced management needs and their positive environmental and economic profiles. Some southern chinch bug populations, termed the polyploid-damaging populations, had overcome the resistance in Floratam within 15 years of its release in 1973 (1). Subsequently, other resistant cultivars, such as Floralawn, 'FX-10' and 'Captiva,' were developed (7,11). It was recently discovered that some Texas populations of southern chinch bug, which appear to be a new virulent biotype (VTSCB-2005), are not susceptible to either Floratam or FX-10 (18). Less than 20% of these chinch bugs of the new biotype were killed by either cultivar within a 7-day feeding period in the laboratory (18).

Identifying the categories of resistance to the southern chinch bug is crucial to the development and screening of resistant St. Augustinegrass genotypes. Plant resistance mechanisms include chemical or physiological defenses that resulted in reduced survival and fecundity of the insects (antibiosis) and morphological or physical defenses (such as pubescence, wax layers, and thick cell walls) that resulted in avoidance and reduced feeding by the insects (antixenosis) (14,15). In studies conducted in Florida and Texas, the resistance in Floratam and Floralawn was classified as antibiosis (7,17) and those in FX-10 and Captiva were classified as antixenosis (14). The impact of infestation by southern chinch bug on the quality of various genotypes of St. Augustinegrass was seldom documented.

Predators of the southern chinch bug, such as ants, anthocorids, big-eyed bug and spiders, are active in St. Augustinegrass lawns (3,4,8,16). Anthocorids and big-eyed bugs had been shown to aggregate at sites of infestation by southern chinch bug and the density of predators correlated positively to the prey density (3,8). The influence of St. Augustinegrass genotypes on the composition and activity of natural enemies is unknown.

The objective of this study was to assess the tolerance levels and antibiotic effects of selected St. Augustinegrass genotypes on the populations of southern chinch bugs and their natural enemies from Georgia and South Carolina.

Tolerance Level in Selected St. Augustinegrass Genotypes

Two separate field studies were conducted on plots of 15 St. Augustinegrass genotypes established at University of Georgia, Griffin Campus, Griffin, GA, and Clemson University Pee Dee Research and Education Center (Pee Dee REC), Florence, SC. Plots were established on sandy loam soil and mowed to a height of 6.6 to 7.6 cm (2.5 to 3.0 inch) at both locations. Fertilizers were applied at a rate of 54 to 97 kg N/ha (1.2 to 2.0 lbs N/1000 ft^2) annually at the Pee Dee REC and 150 to 194 kg N/ha (3.0 to 4.0 lbs N/1000 ft^2) annually at the Griffin Campus. Plots at the Griffin Campus were established in two groups (Griffin 1 and Griffin 2). Plot size at Griffin 1 was 2.4 × 3.6 m (8 ×12 ft) while those at Griffin 2 and Pee Dee REC were 2.4 × 2.4 m (8 × 8 ft). A randomized complete block design was used at all locations. Genotypes tested at Pee Dee REC and Griffin 1 were replicated three times and those at Site 2 were replicated four times. All plots were allowed to be naturally infested as southern chinch bugs dispersed from the surrounding areas. No insecticide was applied to the plots and surrounds from 2006-2008 to control the southern chinch bug populations at these locations.

Tolerance levels of 13 genotypes (Amerishade, 'Classic,' 'Delmar,' Floralawn, Floratam, 'Bitter Blue,' 'Mercedes,' 'MSA 2-3-98,' 'MSA 31,' 'Palmetto,' Raleigh, 'Seville,' and Winchester) were documented at Griffin 1 and six genotypes ('Arkansas,' Floratam, 'Griffin,' Mercedes, Palmetto, and Raleigh) at Griffin 2 in 2006. The cultivars referred to as Arkansas and Griffin were St. Augustinegrass selections from Arkansas and Griffin, GA, respectively. Neither are commercially available or from any known turfgrass breeding program.

Fifteen 10-s suction samples were collected on diagonal transects from each plot at the Griffin Campus (0.02 m^2 per suction for a total of 0.3 m^2 or 3.2 ft^2 per plot) using a 'Vortis' vacuum sampler (Burkhard Manufacturing Co. Ltd., Hertfordshire, UK) on 21 August, 11 September, 6 October, and 13 December 2006. Samples were returned to the laboratory where the immature and adult chinch bugs were sorted and counted.

Tolerance levels of six St. Augustinegrass genotypes (Delmar, Floratam, Mercedes, MSA 31, MSA 2-3-98, and Raleigh) were assessed at Pee Dee REC in both 2007 and 2008. Monthly samples were taken from July to December by pouring tap water into a PVC pipe (0.3 m long and 0.1 m diameter) that was inserted into the soil to form a water seal. Immature and adult southern chinch bugs floated to the surface within a 5-min period were counted on site. Three samples were randomly taken from each plot (a total sampling area of 0.02 m^2 or 0.2 ft^2) on each sampling date. Data from each sampling date were analyzed with one-way ANOVA and the means were separated by Fisher's protected LSD test at a threshold of 0.05 (SAS, SAS Institute Inc., Cary, NC).

The average numbers of southern chinch bugs collected among the genotypes fluctuated between 0 and 217 per 0.3 m^2 at the Griffin Campus (Table 1) and 0 and 212 per 0.02 m^2 at the Pee Dee REC (Table 2) during the entire sampling period. The chinch bug densities at the Pee Dee REC were similar among the six St. Augustinegrass genotypes in July of both 2007 and

2008 (Table 2), suggesting that chinch bug population did not increase until August at this location. At both the Griffin Campus and the Pee Dee REC, the numbers of chinch bugs collected from the resistant cultivars Floratam and Floralawn from August to December were consistently lower than on all other genotypes, while Raleigh was consistently the most heavily infested. Densities on Floratam and Floralawn were at times 99.9% lower than that on Raleigh (Griffin 1 on 11 September 2006). On most sampling dates, Arkansas, Delmar, Griffin, Mercedes, MSA 2-3-98, MSA 31, Seville, Winchester, and Classic harbored more southern chinch bugs than Floratam and Floralawn, but not significantly so. In contrast, the chinch bug densities on Amerishade, Bitter Blue, and Palmetto were not significantly different from Raleigh. Based on the average numbers of chinch bugs over the entire sampling period, the ranking of the density (from lowest to highest) was Floralawn = Floratam < Delmar < Arkansas < Mercedes < Classics < MSA 2-3-98 < Seville < MSA 31 < Winchester < Griffin < Bitter Blue < Amerishade < Palmetto < Raleigh.

The color and quality of the St. Augustinegrass were assessed monthly from August to October 2006 based on the criteria published by National Turfgrass Evaluation Program (10) at Griffin 1. Overall quality ratings were based on a combination of color, density, uniformity, texture, and disease or environmental stress. Numeric color and quality ratings were taken on a scale of 1 to 9 (1 = light green or poorest quality, 6 = acceptable quality, and 9 = dark green or best quality). Plots at the Pee Dee REC suffered from severe stresses from chinch bugs, brown patch and drought in both 2007 and 2008. We believe that the recorded ratings were not reflective of the actual damage caused solely by the southern chinch bugs; therefore, we did not present the color and quality ratings from the Pee Dee REC.

Table 1. Total number of southern chinch bugs per 0.3 m² of St. Augustinegrass in two sites at University of Georgia, Griffin Campus in 2006.

		Sampling date in 2006			
Site	**Genotype**	**21 Aug**	**11 Sep**	**6 Oct**	**13 Dec**
Griffin 1	Amerishade	54.0 abc	141.3 ab	86.0 ab	31.3 bc
	Bitter Blue	56.3 abc	45.3 c	72.7 abc	61.3 ab
	Classic	24.3 bcd	46.7 c	23.3 bcd	18.3 bc
	Delmar	13.3 cd	5.3 c	16.7 cd	11.3 c
	Floralawn	2.7 d	0.3 c	0.0 d	2.0 c
	Floratam	7.3 cd	0.3 c	0.7 d	1.3 c
	Mercedes	28.3 bcd	8.3 c	19.7 cd	15.3 c
	MSA 2-3-98	28.0 bcd	68.0 bc	12.3 cd	27.7 bc
	MSA 31	32.3 bcd	30.3 c	28.3 bcd	26.3 bc
	Palmetto	66.3 ab	69.3 bc	53.3 abcd	39.0 bc
	Raleigh	84.0 a	217.3 a	118.0 a	104.0 a
	Seville	14.7 cd	24.3 c	33.0 bcd	31.3 bc
	Winchester	36.3 abcd	58.0 bc	24.0 bcd	19.7 bc
Griffin 2	Arkansas	31.5 ab	3.0 b	86.7 b	17.0 bc
	Floratam	6.0 b	4.3 b	5.0 b	1.5 c
	Griffin	29.8 ab	3.8 b	115.8 ab	29.3 b
	Mercedes	34.5 ab	12.3 b	72.0 b	26.0 b
	Palmetto	50.5 ab	50.2 ab	97.5 ab	26.3 b
	Raleigh	105.3 a	151.0 a	240.0 a	66.3 a

x Means at each site in each column followed by the same letter are not significantly different according to Fisher's protected LSD at α = 0.05 and are means of three replicates at Griffin 1 and four replicates at Griffin 2.

Table 2. Total number of southern chinch bugs per 0.02 m² of St. Augustinegrass at Clemson University, Pee Dee Research and Education Center in 2007 and 2008.

Genotype	Sampling date in 2007					
	13 Jul	15 Aug	21 Sep	18 Oct	15 Nov	13 Dec
Delmar	3.7	14.7 b	17.0 b	36.7 b	38.7 b	16.3 bcd
Floratam	4.3	14.7 b	22.7 b	3.7 b	1.0 c	1.0 d
Mercedes	2.3	15.0 b	27.3 b	40.3 b	39.7 b	22.3 bc
MSA 2-3-98	3.3	17.0 b	36.7 b	12.7 b	20.0 c	28.0 b
MSA 31	2.0	16.7 b	12.0 b	8.3 b	10.0 c	11.7 cd
Raleigh	2.7	62.3 a	12.6 a	82.7 a	138.3 a	138.7 a
Genotype	**Sampling date in 2008**					
	13 Jul	**15 Aug**	**21 Sep**	**18 Oct**	**15 Nov**	**13 Dec**
Delmar	2.7	17.3 b	22.3 b	33.7 b	32.3 b	21.0 b
Floratam	0.7	1.3 b	1.7 b	0.3 c	0.0 c	0.0 c
Mercedes	2.0	12.7 b	26.3 b	32.7 b	28.7 b	34.7 b
MSA 2-3-98	3.0	20.3 b	25.7 b	24.3 bc	27.3 b	31.3 b
MSA 31	2.0	20.3 b	20.0 b	23.7 bc	31.0 b	14.0 b
Raleigh	3.7	53.7 a	65.7 a	94.0 a	111.3 a	212.0 a

[x] Means from each year in each column followed by the same letter are not significantly different according to Fisher's protected LSD at α = 0.05 and are means of three replicates.

Although Raleigh had the highest density of southern chinch bugs, this cultivar did not appear to suffer significant reduction in color and quality when compared to Floratam, Floralawn, and the other genotypes (Table 3). The color and quality ratings of all genotypes (except Amerishade) were above the acceptable rating of 6. Amerishade scored the lowest, below acceptable (except for color rating in August) color and quality ratings among all the genotypes tested and continued to decline as the season progressed.

Table 3. Color and overall turf quality of St. Augustinegrass in Griffin 1 at University of Georgia, Griffin Campus in 2006.

Genotype	Color			Turf Quality	
	18 Aug	20 Sep	5 Oct	18 Aug	5 Oct
Amerishade	6.3 c	5.8 b	3.2 b	5.8 b	2.3 c
Bitter Blue	7.0 abc	7.0 a	6.5 a	7.0 a	5.7 b
Classic	7.5 a	7.3 a	7.5 a	7.3 a	7.2 ab
Delmar	7.3 ab	7.0 a	7.5 a	7.3 a	7.2 ab
Floralawn	7.2 ab	6.7 a	6.8 a	7.0 a	6.7 ab
Floratam	6.7 bc	6.8 a	6.5 a	6.8 a	6.2 ab
Mercedes	7.3 ab	7.3 a	7.7 a	7.3 a	7.7 a
MSA 2-3-98	7.5 a	7.0 a	7.5 a	7.3 a	7.0 ab
MSA 31	7.2 ab	6.7 a	7.2 a	7.2 a	6.8 ab
Palmetto	7.0 abc	7.0 a	7.2 a	6.8 a	6.5 ab
Raleigh	7.0 abc	7.2 a	7.0 a	7.0 a	5.8 b
Seville	7.3 ab	7.0 a	6.8 a	7.2 a	6.7 ab
Winchester	7.3 ab	7.0 a	7.0 a	7.3 a	6.5 ab

[x] Means at each site in each column followed by the same letter are not significantly different according to Fisher's protected LSD at α = 0.05 and were means of three replicates from Griffin 1.

Antibiosis in Selected St. Augustinegrass Genotypes

A no-choice test was conducted in a greenhouse at the Griffin Campus to assess the antibiosis effects of selected St. Augustinegrass genotypes on the nymphal development and adult fecundity of the southern chinch bug. Nine genotypes (Arkansas, Floratam, Griffin, Mercedes, MSA 2-3-98, MSA 31, Palmetto, Raleigh, and 'Sapphire') were tested in 2006 and four cultivars (Amerishade, Delmar, Floratam, and Raleigh) were tested in 2007. Plugs of each genotype were obtained from the test plots and local sod producers. Plugs were grown on potting mix (Metro-Mix 300, SunGro Horticulture Co. Ltd., Vancouver, Canada) in plastic pots (15 cm or 6 inch diameter).

Individual stolon, still attached to the potted plant, were confined within 32-ml snap-top, plastic cages and infested with either 10 immature or adult southern chinch bugs. Five females and five males were released in cages infested with the adults. The gender of the nymphs could not be determined. Cages were constructed with open-ended plastic tubes (5 cm or 2 inch diameter) with one end capped with mesh screen for ventilation and the other end capped with a plastic lid where a hole was cut with a cork borer. A stolon was fitted through a section of tygon tubing which had been slit to wrap around the stolon. The tubing with the stolon was inserted tightly through the hole on the plastic lid. This design was sufficient to prevent escape of the chinch bugs. The nymphs and adults were collected with a vacuum sampler from infested grass on the Griffin Campus. After 37 days, time for completion of one generation (S. K. Braman, *unpublished data*), stolons in cages were carefully collected from the greenhouse and examined in the laboratory, and the numbers of eggs, nymphs and adults on each caged stolons were recorded. The experimental design was a randomized complete block design with ten replications for each genotype initiated with both nymphs and adults.

In 2006 and 2007, Floratam did not support development or survival of nymphs introduced onto the stolons, but development was successful on all other genotypes (Table 4). Nymphs survived and developed into adults when caged on Arkansas, Delmar, Griffin, and Palmetto, but the numbers were not significantly different from Floratam. The numbers of surviving chinch bugs on Amerishade, Mercedes, MSA 2-3-98, MSA 31, and Sapphire were not different from those on Raleigh.

Table 4. Mean numbers (± SEM) of southern chinch bugs per cage after 10 nymphs or adults were confined for 37 days on various St. Augustinegrass genotypes in 2006 and 2007.

Year	Genotype	Colony initiated with nymphs			Colony initiated with adults			
		Nymph	Adult	Total	Egg	Nymph	Adult	Total
2006	Arkansas	0.0 b	0.9 cd	0.9 cd	5.7 bc	1.2 ab	1.0 cd	7.9 bc
	Floratam	0.1 b	0.0 d	0.1 d	0.0 c	0.1 b	0.1 d	0.2 c
	Griffin	0.1 b	0.9 cd	1.0 cd	7.4 bc	0.0 b	0.4 d	7.8 bc
	Mercedes	0.0 b	2.9 ab	2.9 ab	20.6 ab	0.6 b	4.0 a	25.3 ab
	MSA 2-3-98	0.2 ab	1.7 bc	1.9 bc	5.3 bc	0.0 b	1.4 bcd	6.7 bc
	MSA 31	0.0 b	3.1 a	3.1 ab	17.1 ab	2.8 ab	4.1 a	24.0 ab
	Palmetto	0.0 b	1.3 cd	1.3 cd	16.8 ab	0.3 b	3.1 ab	20.8 ab
	Raleigh	0.4 a	2.8 ab	3.2 ab	24.4 a	4.1 a	2.8 abc	31.3 a
	Sapphire	0.0 b	3.9 a	3.9 a	6.0 bc	3.9 a	0.9 cd	10.8 bc
2007	Amerishade	0.4	2.6 a	3.0 a	4.9	3.9	2.8 a	11.6 ab
	Delmar	0.1	2.2 ab	2.3 ab	13.7	5.6	2.9 a	22.2 a
	Floratam	0.0	0.0 b	0.0 b	0.0	0.0	0.0 b	0.0 b
	Raleigh	0.3	3.5 a	3.8 a	7.8	3.9	2.5 a	14.2 ab

[x] Means from each year in each column followed by the same letter are not significantly different according to Fisher's protected LSD at α = 0.05 and were means of ten replicates.

Reproduction of southern chinch bugs caged on Floratam was also suppressed (Table 4). These results confirm that the category of resistance in Floratam is antibiosis. Egg production occurred on all other genotypes. The total numbers of southern chinch bugs recovered from Arkansas, Griffin, MSA 2-3-98, and Sapphire were not significantly more than those from Floratam in the 2006 test. The southern chinch bug populations were consistently greater on Amerishade, Mercedes, MSA 31, Palmetto, and Raleigh.

Predators Associated with Southern Chinch Bugs

Predators found in the vacuum samples collected from St. Augustinegrass on the Griffin Campus included spiders, ants, rove beetles (*Coproporus* spp. and *Meronera* spp.) (Coleoptera: Staphylinidae), ground beetles (*Agonum* spp. and *Scarites* spp.) (Coleoptera: Carabidae), big-eyed bugs (*Geocorus* spp.) (Hemiptera: Geocoridae), pirate bugs (*Orius* spp.) (Hemiptera: Anthocoridae), and *Lasiochilus palidulus* Reuter (Hemiptera: Lasiochilidae). Ants (the red imported fire ant, *Solenopsis invicta* Buren), spiders, and big-eyed bugs (*Geocoris uliginosus* Say) were the most abundant predators in Florida lawns (3,4).

The most numerous predators collected in this study were *L. palidulus*. Although previously placed in the family Anthocoridae, the subfamily Lasiochilinae has been elevated to family status (21,22). This predator has also been found in association with Florida populations of southern chinch bug (16), but genotypic influence on population levels has not been quantified and may only be a result of the genotypes' susceptibility to southern chinch bug. Although Raleigh supported the highest numbers of chinch bugs, Winchester had the highest season-long average number of *L. palidulus* (Fig. 1). St. Augustinegrass genotypes demonstrating resistance to the southern chinch bug also supported the fewest *L. palidulus*. In previous studies, anthocorids and lasiochilids were most common in St. Augustinegrass compared to other warm-season grasses and were strongly correlated with numbers of chinch bugs and plant hoppers (8). In the present study, *L. palidulus* were abundant in heavily infested turf, but also in some cultivars that had lower levels of chinch bugs, e.g., Mercedes. The biology and ecology of *L. palidulus* are largely unknown. We do not know if this species is a specialist or generalist predator of the southern chinch bug. We could not assess the efficiency of this species as a biological control agent of the southern chinch bug without additional studies.

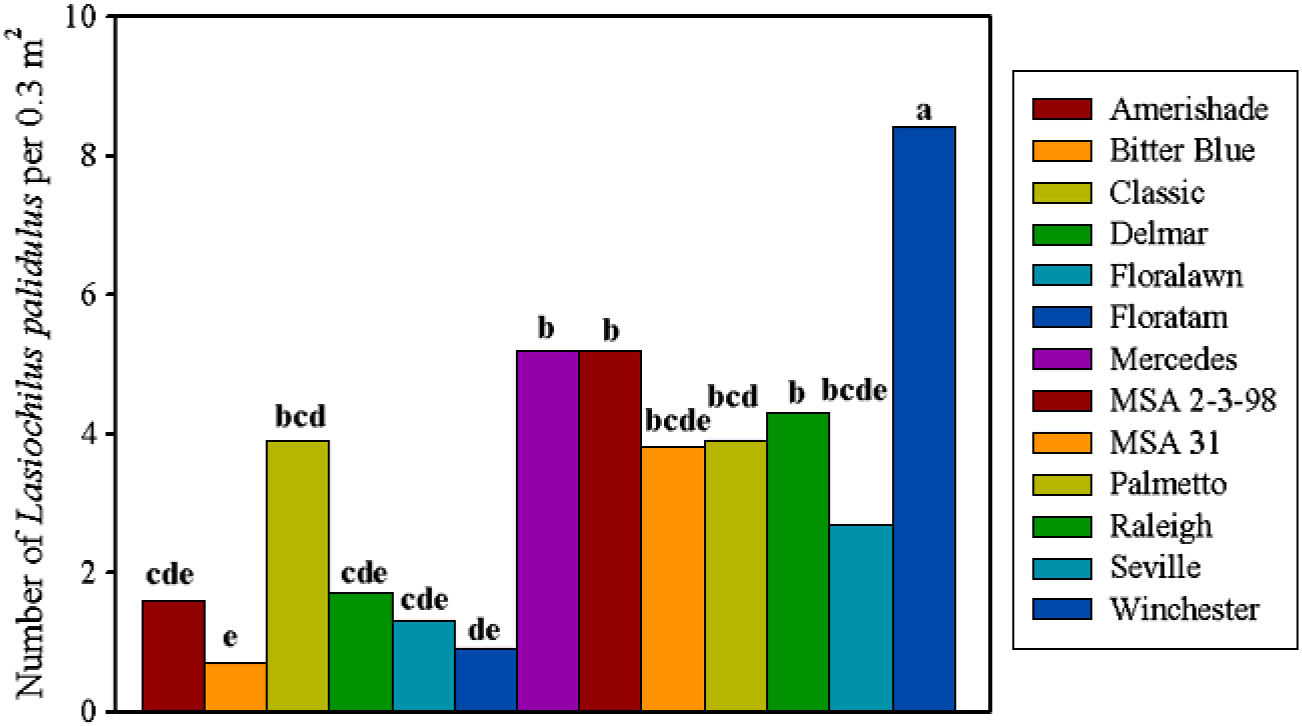

Fig. 1. Season-long average number of *Lasiochilus palidulus* found in the vacuum samples collected from St. Augustinegrass on the Griffin Campus, Griffin, GA.

Conclusions and Recommendations

Although southern chinch bug populations in Florida and Texas have reportedly overcome the resistance in Floratam (1,18), this study showed that Floratam and Floralawn were still resistant to feeding and development of southern chinch bug populations in Georgia and South Carolina. This study also showed that the underlying mechanism of resistance in Floratam was due to the presence of antibiosis which led to the failure of nymphs to complete development to adulthood and of adults to reproduce. Reinert and Dudeck (17) showed that the survival rate of southern chinch bugs was < 50% when feeding on Floratam. Busey and Zaenker (2) suggested that the resistance in Floratam could also be the result of feeding resistance (antixenosis) based on the observations that southern chinch bugs previously feeding on Floratam did not exhibit adverse effects of antibiosis after been transferred to a susceptible host.

The data also indicated different tolerance levels for southern chinch bug infestation among the 13 susceptible St. Augustinegrass genotypes tested. The color and quality ratings of all susceptible genotypes, except Amerishade, were similar to the resistant Floratam and Floralawn in 2006. Although Raleigh was consistently the most heavily infested cultivar, with up to 67 chinch bugs per 0.1 m^2 (1 ft^2) at the Griffin Campus and > 900 chinch bugs per 0.1 m^2 at the Pee Dee REC, it did not appear to be more damaged than other genotypes in the field. This information raises the questions of why some St. Augustinegrass genotypes retained good color and quality despite being infested with a large number of southern chinch bugs and what mechanisms provided the tolerance observed in these genotypes. By identifying the underlying mechanisms of resistance among these tolerant genotypes, we may be able to incorporate these resistant traits into future St. Augustinegrass lines or even other plant species.

The differential tolerance level among St. Augustinegrass genotypes also questions the established treatment threshold against the southern chinch bug. The typical threshold that warrants treatment is 20 to 25 chinch bugs per 0.1 m^2 (13). Over the experimental period, most cultivars did not exceed the threshold and thus no significant reduction in the color or turf quality rating was observed. Reductions in color and quality ratings were observed in Amerishade beginning in August 2006, before the southern chinch bug density even exceeded 20 chinch bugs per 0.1 m^2. Furthermore, Raleigh was not adversely impacted by the densities of southern chinch bug that were always above the treatment threshold.

Natural enemy complex from this study was similar to those from the previous studies (3,4,16), with the exception of the predatory bug *L. palidulus*. *Lasiochilus palidulus* was the most abundant predators found in this study. Although this predator was associated with southern chinch bug population in Florida (16), we do not have information of its biology, prey and habitat preference, and interactions with southern chinch bugs. We did not detect any clearly defined relationship between the abundance of *L. palidulus*, the abundance of southern chinch bug, and the St. Augustinegrass genotypes.

Treatment thresholds are typically established based on the quantitative relationship between the insect density and the observed damage to the plants. Tolerant plant species or cultivars, which could harbor a higher density of pests without significant reduction in yield and quality, should have a higher treatment threshold than the susceptible ones. With the various St. Augustinegrass genotypes exhibiting different tolerance to the southern chinch bug, we suggest that the treatment thresholds should vary among the genotypes. Future research should continue to investigate the relationships among the southern chinch bugs, the predators and the damage to various St. Augustinegrass genotypes, and the establishment of treatment thresholds for individual genotype.

Acknowledgments

We thank Jim Quick of University of Georgia and Fran Wimberly, Leslie Strickland, Ryan Graham, and Albert Lynn of Clemson University for maintenance of plant materials and/or data collection. Jeremy Greene (Clemson University) and two anonymous reviewers provided insightful comments and improvements to an earlier draft of this manuscript. This study was supported in part by CSREES/USDA under project number SC-1700351 (J.-H. Chong) and by the Turfgrass Group (S. K. Braman and F. C. Waltz). Tom Henry, USDA Beltsville Systematic Entomology Laboratory, provided identification of *L. palidulus*. This manuscript is Technical Contribution no. 5591 of the Clemson University Experiment Station.

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