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The Relationship of Chinch Bug (Blissus leucopterus Hemiptera:Lygaeidae) Presence and Abundance to Parameters of the Turfgrass Environment

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THE RELATIONSHIP OF CHINCH BUG (BLISSUS LEUCOPTERUS HEMIPTERA:LYGAEIDAE) PRESENCE AND ABUNDANCE TO PARAMETERS OF THE TURFGRASS ENVIRONMENT

By

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ABSTRACT

THE RELATIONSHIP OF CHINCH BUG (BLISSUS LEUCOPTERUS HEMIPTERA:LYGAEIDAE) PRESENCE AND ABUNDANCE TO PARAMETERS OF THE TURFGRASS ENVIRONMENT

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Selected parameters of the chinch bug (Blissus leucopterus) turfgrass environment were examined over a three year period in a survey of 108 home lawns in the greater Lansing area of Michigan. Variables included were thatch thickness, grass height, dry weight of the grass, chlorophyll content, thatch and ambient temperature, soil moisture, and species composition of the lawn. Numbers of chinch bug and predaceous arthropod were counted using a transect sampling method. Thatch thickness was positively correlated to the abundance of chinch bugs in all three years. It was the only variable that was significantly correlated to chinch bug abundance in all three years. In field experiments thick thatch was induced by applications of the fungicide mancozeb, and chinch bug populations increased. In lawn surveys, thatch grew thicker over a two year period in chinch bug infested lawns, but did not change in non-infested ones. Chinch bugs released into thatchy and dethatched areas appeared to have at least a short-term habitat preference for thatchy turf. Big-eyed bugs (Geocoris bullatus Say) were observed to feed on adult chinch bugs in the laboratory, but confinement with big-eyed bugs did not significantly affect chinch bug population sizes in the laboratory.

There was significantly more fine fescue (Festuca rubra) and less Kentucky bluegrass (Poa pratensis) in infested lawns as compared with non-infested lawns. A linear discriminant function was determined for 1986 data using percent Kentucky bluegrass and thatch thickness as the variables of interest. When tested using data from 1986, 1987, and 1988 the function correctly predicted chinch bug presence in lawns between 63 and 81 percent of the time. In the laboratory, chinch bugs were found to feed more on Kentucky bluegrass than on fine fescue. There was a tendency for chinch bugs to hide in Kentucky bluegrass preferentially over fine fescue, although the difference was not significant.

To Terry

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GENERAL INTRODUCTION

The chinch bug, Blissus leucopterus Montandon (Hemiptera:Lygaeidae), is a native North American insect that has become a major pest of turfgrass. In 1985, Michigan lawn care companies reported it to be the number one turfgrass pest (D. R. Smitley, pers. comm.). Although insecticides provide the major means of control (Niemczyk, 1984), cultural management may be more practical and desirable for urban turf. Reduction of pesticide input may not only reduce human health hazards, but also ameliorate stressed predator or pathogen populations, thus allowing natural enemies to play a role in control of the chinch bug (Knipling, 1979; Tashiro, 1987). Moreover, changes in cultural practices may present a long term solution to outbreaks rather than short term control (Knipling, 1979). A better understanding of the factors that regulate population growth and decline of an insect is the first step in the development of an effective cultural control (Knipling, 1979).

LITERATURE REVIEW

Four species of the genus Blissus are known in North America: leucopterus, insularis, arenarius, and maritimus (Leonard, 1966), but only B. leucopterus and B. insularis are considered economically important. Two subspecies of B. leucopterus, B. l. hirtus and B. l. leucopterus, differ slightly

in morphology, geographic distribution, host preference, and habitat preference, but readily interbreed. It is fruitless to assign a subspecies name where the ranges of the two overlap (Leonard, 1966). Blissus leucopterus hirtus, or the "hairy" chinch bug, typically feeds on northern cool season turfgrasses, whereas B. l. leucopterus generally feeds on grains, such as wheat, corn and sorghum. The range of B. l. hirtus spans a triangle from Minnesota, to Virginia, to Maine. Blissus leucopterus leucopterus has a distribution south of B. l. hirtus, and west to Nebraska, Kansas, Oklahoma, and Texas, although the two have a large area of overlap in Michigan. The southernmost portion of the United States is inhabited by B. insularis, a pest of the warm-season turfgrasses (Leonard, 1966).

The first record of damage by the chinch bug in North America dates to 1783 in North Carolina, when the insect nearly destroyed the wheat crop there (Fitch, 1856). The species Blissus leucopterus was first described in North America by Say in 1831 from a specimen collected on the coast of Virginia. The insect was established as a pest of grains in the Midwest, however widespread damage did not occur until 1864 when grain losses in Illinois were estimated at 73 million dollars (Leonard, 1966). Blissus leucopterus hirtus was first described as a species, B. hirtus, by Montandon (1893) and later given subspecies status by Leonard (1966). Heavy infestations of B. l. hirtus in lawns and golf courses was first reported on Long Island, New York, in 1932 (Maxwell and MacLeod, 1936).

The chinch bug overwinters as an adult, usually in tufts of grass or under plant debris, and often around the foundations of buildings (Leonard, 1966). Diapause is apparently photoperiod induced, with short day length inhibiting mating and feeding behavior (Smith et al., 1981). The bugs become active in the spring when temperatures rise above 7°C (Liu and McEwen, 1979). Eggs are laid in April or May, depending on the latitude. The species is bivoltine in Ohio (Martin, 1976) but may be univoltine in some northern areas (Niemczyk, 1984).

There is some confusion over the base temperature for development of the insect. Liu and McEwen (1979) calculated the base temperature for development to be 7°C. They dissected females kept at various temperatures and determined the minimum temperature for egg development in the ovaries. Mailloux and Streu (1981) determined the base temperature to be 14.6°C. They determined this from observation of development of eggs kept at different temperatures. None of the authors observed the effect of temperature on the development of immature stages. Seven degrees centigrade is taken to be the activity threshhold by most authors (Kennedy,1981; Tashiro, 1987). In this dissertation, 14.6°C is the base temperature used in degree day calculations for development. Approximately 122 degree-days (base 14.6°C) is the minimum for completion of egg development (Mailloux and Streu, 1981).

The insect passes through five nymphal stages (Mailloux and Streu, 1981) and it is these stages that cause the most lawn damage (Duble and Niemczyk, 1979). The early instars are bright red with a white stripe across the abdomen. The later instars become progressively darker, with the fifth instar being a dark brownish black. Development of wing pads increasingly obscures the white stripe in later instars. A taxonomic key that uses head width to distinguish among the nymphal instars appears in Mailloux and Streu (1981). The adult chinch bug is approximately 4.5 mm long, with a black body and yellow legs; the hemelytra are milky-white. In B. l. leucopterus, the setae covering the head are silver-gray , whereas they are straw-yellow in B. l. hirtus (Leonard,1968).

The first instar was found to reach peak population size at 176 degree days and the second instar at 236 degree days(base 14.6°C, Mailloux and Streu, 1981). The number of third and fourth instars, lumped together owing to difficulty in differentiating between them in the field, was found to peak at 334 degree days. Fifth instars peaked at 501 and adults at 637 degree days (Mailloux and Streu, 1981).

The chinch bug feeds by inserting its proboscis into the vascular tissue of a plant and sucking out the sap. The saliva may be toxic to the plant. Feeding damage clogs the plant's conductive tissues, preventing water and nutrients from reaching leaves and new shoots. Prolonged feeding may eventually kill the plant. The damage usually appears as scattered patches in open sunny areas of the lawn which become yellow and brown as the turf dies (Martin, 1976).

Most of the cool season turfgrasses are fed upon by the hairy chinch bug, including the two most common, fine fescue (Festuca rubra) and Kentucky bluegrass (Poa pratensis)(Leonard, 1966, Tashiro, 1987). Other cool-season grasses that serve as hosts are perennial ryegrass (Lolium perenne) and bentgrasses (Agrostis sp.)(Baker et al., 1981a). Leonard (1966) states that bentgrasses are preferred, but gives no empirical evidence. Some feeding preferences for cultivars within grass species are known (Ratcliffe, 1982), but between species preferences are not. Crabgrass (Digitaria sp.) is usually avoided, and is often left undamaged in an otherwise decimated lawn (Leonard, 1966). Significant differences in tolerance to feeding exist among Kentucky bluegrass cultivars (Baker et al., 1981b). Ahmad et al. (1984) report that Kentucky bluegrass does not serve as a host for B. l. leucopterus in Nebraska; this is consistent with its status as a pest of grain crops, not of turfgrass.

It is not clear why chinch bug outbreaks do not occur in all lawns. Four groups of variables which may be important in regulating chinch bug population density are discussed in the literature. These are 1) grass species, 2) lawn health, 3) cultural practices, and 4) natural enemies.

The species of grass present may be an important factor in whether or not a lawn becomes infested. Non-native grass species in Kansas (such as the cool-season turfgrasses) have been shown to be more susceptible to chinch bug attack than indigenous species (Hayes and Johnson, 1925). Differences in tolerance of cultivars of turfgrasses to chinch bug feeding have been identified and may explain discrepancies in host range descriptions (Ratcliffe, 1982). Antibiosis has been shown in some cultivars of Kentucky bluegrass (Ahmad et al., 1984). Ramoska and Todd (1985) demonstrated a reduced infectivity rate by the insect pathogenic fungus Beauveria bassiana when B. l. leucopterus was fed on corn or sorghum, as compared to bugs fed on barley, wheat, artificial diet, or water alone. Efficacy of pathogens may also differ for B. l. hirtus depending on host plant.

The health of the lawn may play a role in chinch bug attack. The chinch bug is commonly described as a dry weather insect, being most often reported in abundance in hot dry years (Flint et al., 1935; Mailloux and Streu, 1981; Schread, 1970). Guthrie and Decker (1954) found that dry weather favors longevity if food is available. The greatest injury to turf occurs during July and August, when it is drought stressed (Duble and Niemczyk, 1979). However, it is not clear from the literature whether drought-stressed lawns are attractive to the chinch bug, conducive to population growth, or whether damage is simply more apparent on these lawns.

Turf cultural practices may influence the susceptibility of a lawn to chinch bug damage. One way this is possible is through pesticide-induced suppression of natural enemies. Hairy chinch bug populations were shown to increase following several years of treatment with chlordane (Streu and Cruz, 1972; Streu and Vasvary, 1966). The southern chinch bug, Blissus insularis, is known to be resistant to organophosphate pesticides in Florida (Reinert and Portier, 1983). An increase in B. l. hirtus numbers in chlordane treated plots was more likely to have been caused by reduced chinch bug predator pressure, as chinch bug population increases were correlated with reductions in predaceous mite species (Streu, 1973), but a direct cause and effect was not established. In general, insecticide applications have been shown to greatly reduce predaceous arthropod populations in turf (Cockfield and Potter, 1983). Fungicides have also been shown to eliminate naturally occurring insect pathogenic fungi on potatoes (Loria et al., 1983); they may have similar impact in turfgrass.

Various components in fertilizer used in turf culture may also influence susceptibility of a lawn to damage. Sorghum resistance to chinch bug attack was substantially reduced by treatment with sodium nitrate but its resistance was significantly increased by treatment with phosphate (Dahms and Fenton, 1940).

Several biotic factors have been determined to be important in chinch bug population regulation. Five egg mortality factors have been identified, which result in a 48% reduction in population size The five factors are: 1) Eumicrosoma beneficum Gahan, a hymenopteran parasite (Scelionidae), 2) Amara sp. (Carabidae) which preys on eggs, 3) desiccation, 4) an undescribed fungal disease, and 5) failure to hatch due to unknown causes (Mailloux and Streu, 1981).

Factors causing mortality of nymphs and adults are not as well defined. Wet thatch causes mortality of the first instars during eclosion (Mailloux and

Streu, 1981). Although chinch bug predators were shown by Mailloux and Streu (1981) not to have an important effect, other authors (Cruz, 1972; Niemczyk, 1984) have identified the big-eyed bug, Geocoris bullatus, as an important predator. At present no empirical evidence has been published. Leonard (1966) points out that it is not known whether the big-eyed bug actually preys on the chinch bug or whether they simply have similar habitat preferences. Parasitoids have never been observed to emerge from nymphs or adults (Mailloux and Streu, 1981).

The fungal pathogen Beauveria bassiana is a significant mortality factor, reducing generation sizes by about 17% (Mailloux and Streu, 1981). Ramoska (1984) found conidia to be invasive and pathogenic at all relative humidities tested, although production of conidia only occurred in chinch bugs incubated at 75% relative humidity or higher.

Winter mortality ranges between 28 and 68% in Metuchen New Jersey, depending on the severity of the winter (Mailloux and Streu, 1981). Leonard (1966) reports a winter mortality of 34% in Mansfield, Connecticut. Decker and Andre (1936) showed that the ability of chinch bugs from Iowa to withstand freezing temperatures is relatively low. Minimum temperatures recorded in the northern half of the United States should be sufficient to cause 100% mortality. They suggest that the insulation provided by dead grass, leaves, and snow cover is essential to the over-wintering survival of the chinch bug.

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CHAPTER 1

Relationship of Chinch Bug (Blissus leucopterus Hemiptera:Lygaeidae) Abundance to Parameters of the Turfgrass Environment.

INTRODUCTION

The chinch bug, Blissus leucopterus Montandon (Hemiptera:Lygaeidae), a native of North America, is a major pest of the imported cool-season turfgrasses (Tashiro, 1987). Although insecticides provide the usual means of control (Niemczyk, 1984), alternative management strategies are more desirable, given the increased concern over pesticide use in the urban environment. If the LD_{50} is used as an indicator of health risk, insecticides could be targeted by environmental action groups because insecticide LD_{50}'s are generally lower than those of herbicides, fungicides, or of fertilizers used on turfgrass (Anonymous, 1986). In addition to environmental and health concerns, home lawn insecticide applications may also be undesirable owing to their broad spectrum toxicicological effects on predaceous arthropods that normally regulate populations of chinch bugs and other turfgrass insect pests (Cockfield and Potter, 1985; Knipling, 1979; Reinert and Portier, 1983; Tashiro, 1987). Moreover, practical cultural management strategies are more desirable, as they present long term solutions rather than short term controls for outbreaks (Knipling, 1979).

Reliable cultural control practices cannot be developed until more is learned about the probable causes of chinch bug outbreaks in home lawns. Cultivar susceptibility, predator suppression and moisture stress have been suggested as likely factors causing chinch bug outbreaks. Cultivar selection could be an important factor. Kentucky bluegrass cultivars differ significantly in susceptibility to chinch bug damage (Ratcliffe, 1982; Baker et al., 1981). Field populations of chinch bugs were affected differentially by cultivars of perennial ryegrass, although survival rates on these cultivars did not differ (Ratcliffe, 1982). Predator suppression may also be a factor. Lawns with high fertilizer and pesticide input have fewer predators (Cockfield and Potter, 1985) and a higher probability of having chinch bug problems (Duble and Niemczyk, 1979). Thatch has been noted as being a significant factor for populations of the southern chinch bug, Blissus insularis (Reinert and Kerr, 1973), but there is no evidence as to how thatch affects the species. Niemczyk (1984) hypothesized that chinch bug injury is more likely during periods of moisture stress. Irrigation or rainfall may also suppress chinch bug numbers below damaging levels (Duble and Niemczyk, 1979). Unfortunately, experimental data supporting drought stress, predator suppression, and thatch as factors influencing hairy chinch bug outbreaks are lacking.

In this investigation I sought to describe the relationship between home lawn characteristics and chinch bug infestations through a survey of randomly selected lawns in the greater Lansing, Michigan area. Data were collected on chinch bug and predaceous arthropod populations, grass health parameters including chlorophyll content and dry weight, and abiotic factors including temperature of the microenvironment and soil moisture. Additional lawn parameters included grass height, thatch thickness and species composition of the lawns. The intent was to develop a database for discriminating between favorable and unfavorable chinch bug habitats in the turfgrass environment.

MATERIALS AND METHODS

1986 Survey. Home lawns in the Lansing Michigan area were selected by requesting permission for the use of the lawns of the faculty and staff of several departments in the College of Natural Science at Michigan State University. Each of 126 lawns was sampled once for the presence of chinch bugs with a ten minute visual inspection of the grass and thatch, during late June or July. A lawn was determined to have a chinch bug population if one or more chinch bugs were found. A total of 28 chinch bug infested lawns were identified from the 126 lawns sampled. During the week of August 12 to August 19, 1986, several additional attributes were estimated by sampling the 28 infested lawns as well as 16 randomly selected non-infested lawns. Four types of information were collected from each lawn: arthropod population densities, grass health parameters, abiotic parameters, and lawn parameters.

1. Arthropod population densities--The grass, thatch, and exposed soil were visually inspected for chinch bugs within a 1.5 m long, 2.5 cm wide transect. The transect was defined by a loop of string stretched around two one inch wide row markers placed five feet apart. Five randomly placed transects per lawn were thoroughly searched, with search time varying between three and five minutes, depending on the density of the grass. Predaceous arthropods were also counted during this time. All sampling was conducted between 9 AM and 7 PM.

2. Grass health parameters--Grass plant density and chlorophyll content were measured as indicators of grass health. Grass density was estimated by taking samples of grass with a 7.6 cm metal clip. When the clip was squeezed open and allowed to close on grass blades it effectively collected all blades in a 2.5 by 7.6 cm patch. The grass trapped in the clip was cut off at soil level using scissors. This was repeated three times in each lawn. The samples were dried at 60° C for 24 hours and then weighed. In this way the dry weight of a standardized area of turf was measured.

Chlorophyll content of the grass was measured by suspending 0.25 g of dried grass blades in methanol for 24 hr. Aliquots were analyzed with a Beckman spectrophotometer as described by Johnson (1974).

3. Abiotic parameters--Stratified air temperature data and soil samples for determining soil moisture were collected at each lawn. Air temperature was measured at three levels, in the thatch layer, 15 cm and 1.2 m above thatch, using a shaded thermometer. Five cm deep soil cores were taken with a 2.5 cm diameter cork borer and placed into pre-weighed vials. Vials with soil were weighed and then dried at 60° C for 24 hours. After drying, they were again weighed, allowing computation of percent soil moisture for three samples per lawn.

4. Lawn parameters--Thatch thickness and grass height were measured to the nearest mm at three randomly selected points in the lawn. Species composition of the lawn was determined by removing one plant every 30 cm along a 3 m long transect randomly placed in the lawn. The transect sample was replicated five times, making a total of 50 plants sampled per lawn. Grass and weed plants were placed in a plant press and samples were later determined to species using Turgeon and Giles (1984). These data were taken for only six of 16 non-infested lawns.

1987 Survey. Data from 27 infested lawns and 15 non-infested lawns were collected in early July and again in late August to determine chinch bug abundance, thatch thickness, grass height and grass species composition. Most of the lawns intensively surveyed in 1986 were included again in the 1987 survey. For logistical reasons, seven of the non-infested lawns were replaced with new non-infested lawns One of two infested lawns was replaced for the same reason, the other had an insecticide treatment applied by the homeowner. From 1986 to 1987, one infested lawn became non-infested and one non-infested became infested. Only parameters that showed a relationship to chinch bug abundance in 1986 based on a correlation analysis (SAS Institute, 1985) were used again in 1987. These were thatch thickness, grass height, and lawn composition. Thatch thickness and grass height were measured to the nearest mm at five random points in the lawn on both sampling dates. Lawn species composition was determined as in 1986.

1988 Survey. A new set of lawns was identified for use in validating a discriminant function determined from the 1986 data. Streets in the Lansing area were selected from map listings using a random number generator. Potential study lawns on each selected street were also randomly selected. Of 112 homeowners that were approached, 66 responded favorably to inclusion of their lawn in this study. Of those 66 lawns, 14 were found to have chinch bugs. Chinch bug abundance, thatch thickness, grass height and species abundance were determined as previously described. Survey was conducted from July 22 to August 10, 1988.

Data analysis. Data were analyzed using Statistical Analysis Systems (SAS Institute, Inc., 1985). All percentage data were arc sin square root transformed before analysis. Discriminant analyses were done with prior probabilities proportional. A discriminant function was written using the 1986 data and was used to test the 1987 and 1988 data. Five leave-five-out jackknife tests of the 1986 data were done (Sokal and Rohlf,1981).

RESULTS

Of all the variables surveyed in 1986, only thatch thickness and grass height were found to be significantly correlated with chinch bug abundance (r= 0.444, p=0.023, and r=0.563, p=0.003, respectively, Table 1). These variables were also significantly correlated with each other (r= 0.622, p=0.0001, Table 1). In 1987 thatch thickness was again significantly correlated to chinch bug abundance (r=0.429, p=.025, Table 2) but grass height was not (r=-0.176, p=0.379, Table 2). Thatch thickness and grass height were not correlated with each other in that year (r= 0.266, p=0.179). Again in 1988, thatch thickness was the only variable significantly correlated with chinch bug abundance (r=0.252 P=0.041, Table 3).

In all three years, percent fine fescue (*Festuca rubra*) and percent Kentucky bluegrass (*Poa pratensis*) were significantly negatively correlated (Tables 1, 2 and 3). Kentucky bluegrass and fine fescue were the most commonly occurring turfgrasses, with Kentucky bluegrass occurring in 98% of all lawns sampled and fine fescue occurring in 79%. Chlorophyll content of the grass was positively correlated to soil moisture and to grass height (r=0.414, p=0.015, and r=0.467, p=0.005, respectively, Table 1).

When lawns were classified as infested or non-infested, significant differences were found in the thatch thickness and species composition. Thatch was significantly thicker in lawns infested with chinch bugs. Infested lawns had an average of 8.9 mm thatch whereas non-infested averaged 5.1 mm (t=3.52, 0.001<P<0.002). Lawns that had chinch bugs had more fine fescue and less Kentucky bluegrass than lawns that did not have chinch bugs (Figure 1). Infested lawns had an average fine fescue composition of 35%, compared to 12% in non-infested lawns (t=5.31, P<0.0001). Infested lawns had an average Kentucky bluegrass composition of 42%, compared to 62% in non-infested lawns (t=4.12, P< .0001). Proportions of other grass and weed species, either considered separately or as one group, were not significantly different between infested and non-infested lawns.

Table 1. Correlation coefficients of lawn parameters in 1986. Probability of r is reported in parentheses. For chinch bug abundance, n=28, for all other variables, n=34.

	moisture	T 0	pkb	pff	ght	dwt	chl	tth	prd
Temperature at 0"	.147	-							
(T 0)	(.405)								
Percent Kentucky	.148	-.0160		-					
bluegrass (pkb)	(.402)	(.926)							
Percent fine fescue	.066	.073	-.548	-					
(pff)	(.711)	(.682)	(.000)*						
Grass height	.254	-.019	.104	.050	-				
(ght)	(.146)	(.916)	(.560)	(.780)					
Dry weight	.045	-.130	.082	.102	.334	-			
(dwt)	(.800)	(.463)	(.643)	(.564)	(.054)				
Chlorophyll content	.414	-.259	.296	-.336	.467	-.008	-		
(chl)	(.015)*	(.139)	(.088)	(.052)	(.005)*	(.965)			
Thatch thickness	.281	.108	.026	-.070	.622	.098	.191	-	
(tth)	(.107)	(.544)	(.882)	(.693)	(.000)*	(.582)	(.279)		
Predators	.233	-.008	.203	-.245	.228	.009	.107	.398	-
(prd)	(.233)	(.969)	(.245)	(.156)	(.243)	(.964)	(.587)	(.036)*	
Chinch bug abundance	.312	.227	.064	.063	.563	-.004	.136	.444	.151
	(.121)	(.264)	(.756)	(.760)	(.003)*	(.986)	(.508)	(.023)*	(.444)

Table 2. Correlation coefficients of lawn parameters in 1987. Probability of r is reported in parentheses. For chinch bug abundance, n=22, for all other variables, n=27.

	pkb	pff	ght	tth
Percent Kentucky bluegrass (pkb)	-			
Percent fine fescue (pff)	-.763 (.0001)*	-		
Grass height (ght)	.282 (154)	-.061 (.762)	-	
Thatch thickness (tth)	.266 (.180)	-.002 (.992)	.266 (.179)	-
Chinch bug abundance	-.108 (.591)	.301 (.127)	-.176 (.379)	.429 (.025)*

Table 3. Correlation coefficients of lawn parameters in 1988. Probability of r is reported in parentheses. For chinch bug abundance, n=14, for all other variables n=66.

	pkb	pff	ght	tth
Percent Kentucky bluegrass (pkb)	-			
Percent fine fescue (pff)	-.512 (.0001)*	-		
Grass height (ght)	-.084 (.503)	.098 (.435)	-	
Thatch thickness (tth)	.122 (.329)	-.038 (.759)	.152 (.223)	
Chinch bug abundance	.150 (.227)	-.026 (.834)	.173 (.166)	.252 (.041)*

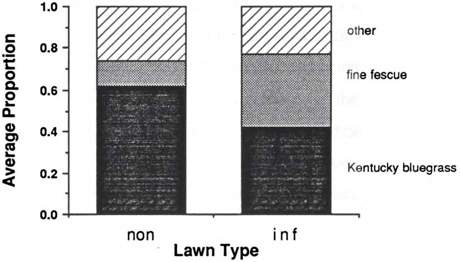

Figure 1. Average proportion of chinch bug infested (inf) and non-infested (non) lawns composed of Kentucky bluegrass, fine fescue, and other plants.

Thatch thickness and species composition data were analyzed with a discriminant function. The function is a vector with coefficients for the lawn variables being analyzed. Coefficients for parameters of the function are listed in Table 4. The values for the variables were multiplied by the NON coefficients and then added to the NON constant for a non-infested computation and multiplied by the INF coefficients and then added to the INF constant for an infested computation. The calculation (INF or NON) giving the largest value gives the predicted chinch bug habitat status of the lawn. The 1986 data were used to write the function, and the 1987 and 1988 data to validate it. Although the covariance matrices were determined to be non-homogeneous (X^2=17.18, $P<0.001$), pooled matrices were used. The SAS stepwise selection procedure for discriminant function variables (SAS Institute, 1985) selected thatch thickness and percent Kentucky bluegrass as the first two variables for inclusion in the model. They were the only two variables determined to be significant for the model at the 0.10 level. The initial discriminant function (1986 data) correctly discriminated non-infested lawns 63% of the time and infested lawns 78% of the time (Table 5). In independent tests, the function identified non-infested lawns correctly 75% and 71% of the time and infested lawns correctly 81% and 64% (1987 and 1988 data, respectively, Table 5). Five leave-five-out jackknife tests of the 1986 data gave a range of correct classification of non-infested lawns from 62 to 75%, and of infested lawns from 70 to 83%.

The tests of the discriminant function using the 1986, 1987, and 1988 data are graphically represented in Figures 2, 3 and 4. The curve on these figures represents the points at which the infested and non-infested equations of the discriminant function are equal. It was determined by setting the two equations equal to each other, holding one of the two variables constant and

Table 4. Coefficients of linear discriminant function. Values of variables are multiplied by the appropriate coefficient and then added to the constant. The calculation giving the larger number is the predicted habitat type of the lawn in question, either chinch bug habitat (INF) or not chinch bug habitat (NON).

	Predicted Chinch Bug Habitat Status of the Lawn	
Variable	INF	NON
Thatch thickness	.101	-.002
% Kentucky bluegrass *	9.601	12.865
Constant	-5.401	-3.382

* function was calculated using arc sin square root transformed data.

Table 5. Computer classifications of infested (INF) and non-infested (NON) lawns using percent Kentucky bluegrass and thatch thickness variables. Data from 1986 were used to calculate the initial discriminant function. Data from 1987 and 1988 are independent tests of the function. Underlined values are percent correct classification for each group.

			Actual Classification as (%)	
Year	Group		NON	INF
1986	NON	8	63	38
	INF	27	22	78
1987	NON	16	75	25
	INF	27	19	81
1988	NON	52	71	29
	INF	14	36	64

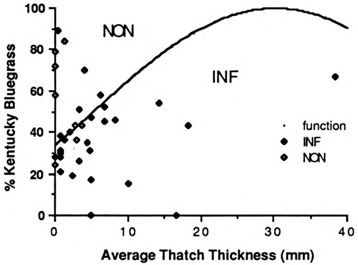

Figure 2. Plot of thatch thickness and species composition data from 1986 showing relative relationship to discriminant function line. Points falling below the line are classified by the function as chinch bug habitats (INF). Those above the line are classified as non-chinch bug habitats (NON). Sixty-three per cent of the non-infested lawns are correctly classified (i.e.fall above the line), as are 78% of the infested lawns (i.e. fall below the line).

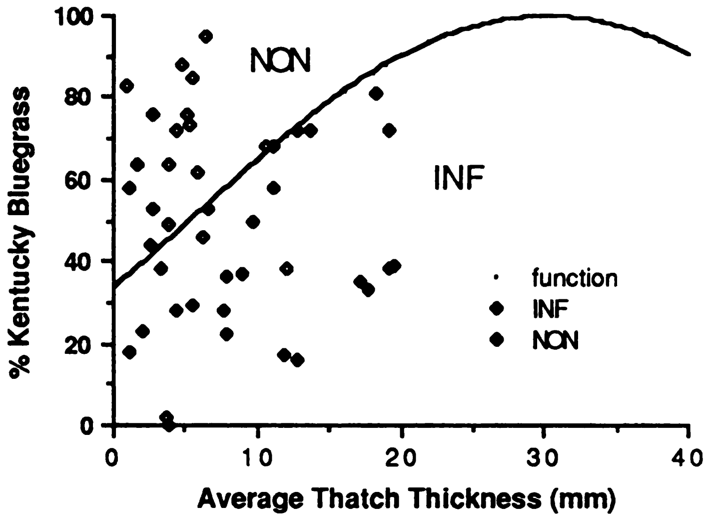

Figure 3. Plot of thatch thickness and species composition data from 1987 showing relative relationship to discriminant function line. Points falling below the line are classified by the function as chinch bug habitats (INF). Those above the line are classified as non-chinch bug habitats (NON). Seventy-five per cent of the non-infested lawns are correctly classified (i.e.fall above the line), as are 81% of the infested lawns (i.e. fall below the line).

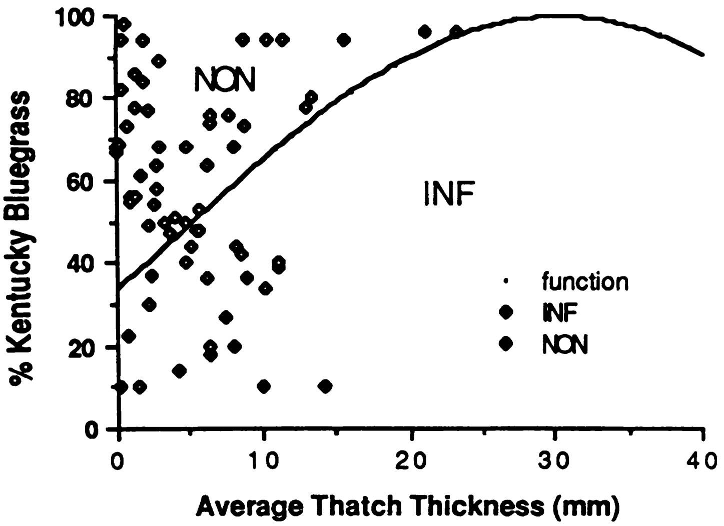

Figure 4. Plot of thatch thickness and species compostion data from 1988 showing relative relationship to discriminant function line. Points falling below the line are classified by the function as chinch bug habitats (INF). Those above the line are classified as non-chinch bug habitats (NON). Seventy-one per cent of the non-infested lawns are correctly classified (i.e.fall above the line), as are 64% of the infested lawns (i.e. fall below the line).

solving for zero. The solid diamonds on the figures represent data for lawns that were in reality infested, and the open diamonds, data for lawns that in reality had no chinch bugs. If the value fell below the line, the lawn was predicted as being infested (INF), if above the line, as non-infested (NON).

DISCUSSION

Thatch thickness and species composition of the turf were found to be consistently related to chinch bug presence in lawns. Thatch, defined as a tightly intermingled layer of living and dead roots, stems, and grass blades that develops between the green vegetation and the soil (Beard, 1973), was associated with both the presence and abundance of chinch bugs in lawns. Thatch was thicker in lawns with chinch bugs than in lawns without them, and as thatch thickness increased, the number of chinch bugs also increased (Tables 1, 2, and 3). The correlation between thatch thickness and grass height in 1986 probably explains the significant correlation between grass height and chinch bug abundance in the same year. Apparently thatch thickness is a more reliable indicator of chinch bug abundance because thatch thickness remained positively correlated to chinch bug abundance in 1987 and 1988 whereas grass height did not.

Thatch thickness was also positively correlated to the abundance of predators in a lawn (Table 1). The presence of thatch makes for a more diverse turf environment, and probably allows for a more complex trophic organization, hence the presence of more upper-level food web members. If reduction in predators was the primary cause of chinch bug outbreaks, a mathematical relationship between chinch bug and predator abundances would be expected. In this study, however, predator counts were not significantly correlated to chinch bug counts (Table 1).

Species composition of a lawn was also an indicator of the presence or absence of chinch bugs. Significantly higher percentages of fine fescue and lower percentages of Kentucky bluegrass in infested lawns suggests chinch bugs are cueing in to some factor associated with fine fescue. Turgeon (1985) indicates that Kentucky bluegrass lawns tend to be slightly thatchier than fine fescue lawns. This is inconsistent with my finding that there is no correlation between thatch thickness and percent fine fescue or percent Kentucky bluegrass (Table 1). Species composition and thatch thickness are independent of each other in my data sets.

My data do not lend support to the hypothesis that moisture stress can account for chinch bug outbreaks. Chlorophyll content is known to be related to drought stress of turf. During periods of moisture stress, the plant reduces chlorophyll production (Kramer, 1983). My data also show that as soil moisture went down, so did the chlorophyll content (Table 1). However, no relationship between chinch bug abundance and chlorophyll content of the grass or soil moisture was found (Table 1). Mattson and Haack (1987) point out that insect response to drought stress is probably non-linear. For the insect, there is an optimum stress level of the plant, after which the insect does less well reproductively or developmentally. Linear correlation may not be the best way to investigate the relationship of chinch bugs to drought stress of the turf.

The discriminant function developed with thatch thickness and species composition data is significant for two reasons. First, such relatively high levels of discrimination (63 to 81%, Table 5) using a function written with only two variables indicates the close relationship of these variables to chinch bug presence in a lawn. Although this relationship can only be said to be correlative and not cause and effect, it does indicate a direction for future research on variables important to chinch bug development. Cultural practices that reduce thatch may also be helpful for chinch bug management.

Further investigation of why lawns with chinch bugs differ in species composition from lawns without chinch bugs could be useful. A certain proportion of fine fescue and Kentucky bluegrass may favor chinch bug development or survival. Another hypothesis to consider in future work is that chinch bug feeding activity may be selecting against Kentucky bluegrass and for fine fescue.

Second, this discriminant function may have practical application. Discriminant functions have been previously used as aids in management decisions (Anderson and Shugart, 1974; Conner and Adkisson, 1976; Hand,1981). It may be useful for lawn-care professionals to establish a chinch bug risk factor for a lawn based on parameters that are relatively easy to measure. High risk lawns (those determined to be potential chinch bug habitats) could be more intensely monitored for chinch bugs, thus more efficiently allocating monitoring time.

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CHAPTER 2

Influence of Thatch Layer on Populations of Chinch Bugs (Blissus leucopterus Hemiptera:Lygaeidae) in Turfgrass

INTRODUCTION

Thatch is defined as a layer of living and dead roots, stems, and grass blades that develops between the green vegetation and soil surface in turfgrass. Excessive accumulation of thatch, such as 1.2 cm or more on a Kentucky bluegrass turf, is considered to be undesirable. In addition to increasing disease problems and decreasing drought stress and effectiveness of pesticides, thick thatch can contribute to insect problems (Beard, 1973). The hairy chinch bug (Blissus leucopterus Montandon Hemiptera:Lygaeidae) is a major pest of turfgrass in eastern North America (Tashiro, 1987), especially on home lawns. It has been suggested that chinch bugs are more likely to be found in turfgrass with thick thatch (Niemczyk, 1981). However there are no experimental data to support this. What benefit heavy thatch may give chinch bugs is not clear. Kennedy (1981) suggests that heavy thatch may provide protection for nymphs and overwintering adults. The insects are known to seek thatch or debris in which to overwinter, suggesting that this type of environment is beneficial to survival through the cold months. The thick spongy thatch produced by St. Augustine grass provides a refuge for the southern chinch bug (Blissus insularis (Say), Reinert and Kerr, 1973), perhaps imparting protection from predators or from desiccation.

We investigated the relationship of thatch to chinch bug abundance by: (1) artificially inducing thatch in the field to determine the effect on chinch bug populations; (2) collecting and releasing chinch bugs into thatched and dethatched areas to observed short term habitat preferences; (3) investigating the effect of thatch on predation of the chinch bug by the big-eyed bug in the laboratory; and (4) surveying lawns in the Lansing, MI, area.

MATERIALS AND METHODS

Induced Thatch Experiment

A population of chinch bugs in the lawn of the Botany and Plant Pathology Field Research Center (Michigan State University, East Lansing, MI) was studied during 1986 and 1987. In 1986, eight 36.6 m^2 plots were established in a chinch bug infested area of the lawn. All plots received full sun. Four of the plots were designated as controls and the other four were treated biweekly with the fungicide mancozeb ("Dithane M-45", Rohm and Haas) at 2.35 oz AI/1000 ft^2 in 4 gal. water per 1000 ft^2, approximately 60% of the lowest recommended rate for this product. Mancozeb is known to increase thatch accumulation (Smiley et. al, 1985). Chinch bugs were sampled by visually searching a 930 cm^2 area for 3 min. Numbers of instars one and two were lumped together, as were numbers of instars three and four, due to difficulty in differentiating between these instars in the field. Four counts were made per plot. Plots were sampled approximately biweekly for a total of eight counts. Notes were made as to the presence of dead insects sporulating with fungi. Dead chinch bugs that were sporulating with a white powdery fungus were noted. The first count was taken on May 28 and the last on October 10. Peak population sizes of instars were interpolated as the value at the 50% point of the cumulative total chinch bugs observed in each instar group.

In 1987, fourteen 36.6 m^2 plots were established in a different area of the same lawn used in the 1986 experiments. Seven were treated biweekly with mancozeb, the other seven were designated as controls. Because the distribution of chinch bugs is known to be clumped (Liu and McEwen, 1979), a transect method was used to sample in 1987. Transects were defined by a loop of string stretched between two 2.5 cm wide wooden row markers placed 1.5 m apart. Chinch bugs were sampled weekly using six randomly placed transects per plot. Instars one and two or three and four were grouped together in counts. A total of 19 counts were made; the first on May 4 and the last on September 17. Degree days were calculated using the Baskerville-Emin (1969) method with a base of 15°C (rounded up from 14.6°C, Mailloux and Streu 1981).

One hundred and sixty insects (twenty from each plot) were collected on Sept. 22, 1986, and brought back to the lab. They were individually placed in tissue culture wells filled with a thin layer of plaster of Paris. Each mini-sporulation chamber was kept moist by introducing water through a small needle hole in the lid over each well. Mortality and incidence of fungus sporulation for the bugs was recorded. Fungi were identified as Beauveria bassiana by microscopic examination (Barnett and Hunter,1972).

Dethatching Experiment

Eight 3.7 m^2 plots , were dethatched using a "Mataway" dethatching machine in a mature stand of "Jamestown" fine fescue at the Hancock Turfgrass Research Center (Michigan State University, East Lansing, MI) during August of 1988. Thatch thickness ranged from 10 to 50 mm. Two 3.7 m^2 non-dethatched plots and two 3.7 m^2 dethatched plots were arranged inside a 14.8 m^2 block such that the dethatched plots were diagonal to each other and adjacent to non-dethatched plots on two sides. Each block was surrounded by aluminum lawn edging sunk to a height of 12.7 cm to discourage chinch bug migration out of blocks. Four such blocks were used. On August 10, 100 adult chinch bugs were released into the center of each of the four plots in each block , for a total of 1600 bugs used. These bugs had been recently collected from an East Lansing lawn that was 94% Kentucky bluegrass and 6% fine fescue. Three-minute visual counts of a 930 cm^2 area in the center of each plot were made at 1, 3, and 5 days post-release.

Predation Experiment

Thatched and non-thatched chambers were set up in the lab during July and August of 1988. Slabs of turf were taken from a mature stand of "Jamestown" fine fescue at the Hancock Turfgrass Research Center. Thatch thickness in this turf ranged from 10 to 50 mm. A small section of the turf slab containing approximately twelve 30 mm tall grass plants was placed on top of moist silica sand in a 2 oz. clear plastic diet cup. Thatch material removed from the same slab was added to the chamber, surrounding the plug of turf to a depth of 10 mm. A hole covered with mosquito-netting in the lid of the chamber provided ventilation. Non-thatched cups were prepared using slabs of turf from a dethatched section of the same area. No thatch was added to these cups, leaving the area around the plug of turf as exposed silica sand. On August 5, twenty adult chinch bugs collected from five different lawns were added to each of 10 thatched and 10 non-thatched cups. After a 10 minute acclimation period, 0, 2, 4, 8, or 16 adult big-eyed bugs (Geocoris bullatus (Say); identified to species at The Center for Insect Identification, Lansing, Michigan) collected from three lawns were added to the chambers. There were two replicates of each treatment type, for a total of 20 chambers. Chambers were maintained for seven days in an air-conditioned room with temperatures between 25 and 27 ° C and relative humidity between 72 and 80%. The chambers were then dismantled and live and dead bugs counted. The experiment was repeated August 26 to September 1. Then, numbers of big-eyed bugs that were added were changed to 0, 10, 20, and 30 per chamber, for a total of eight thatched and eight non-thatched chambers.

Survey

One hundred and eight lawns were surveyed in the Lansing Michigan area in 1986 and 1987 as part of a larger study on relationships of lawn parameters to chinch bug abundance (see Chapter 1). A subset of 25 infested and nine non-infested lawns were sampled for the two consecutive years. Numbers of insects in five transects per lawn were counted to estimate chinch bug abundance. Transects were sampled as described under the induced thatch experiment. Thatch was measured to the nearest mm at five randomly selected points in each lawn and an average thatch thickness was calculated.

RESULTS

Induced Thatch Experiment.

In both years the fungicide treated plots supported larger average populations of chinch bugs than did the control plots (Figures 5 and 6). Chinch bug population densities in fungicide treated plots were compared to that in control plots by fitting linear regression models (SAS Institute, 1985) to fungicide and control data and determining if the slopes were different. In 1986, the linear model of chinch bug population density in control plots had a slope of 0.067 whereas the slope for chinch bug population model in fungicide treated plots was .137. The two slopes were significantly different ($t=2.514$, $df=10$, $0.02<P<0.05$). In 1987, the slope of the chinch bug population development model for control plots was 0.093 and the slope for fungicide treated plots was 0.187 ($t=7.40$, $df=26$, $P<0.001$).

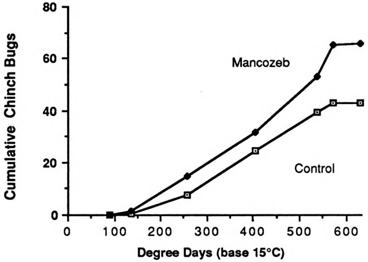

Figure 5. Cumulative number of chinch bugs in control and mancozeb treated plots in 1986. Data are sums of average number of bugs observed in 3720 cm^2 in each of 4 plots. Slopes of lines are significantly different (control: m=.0665, mancozeb: m=.137, t=2.51, df=10, .02<P<.05).

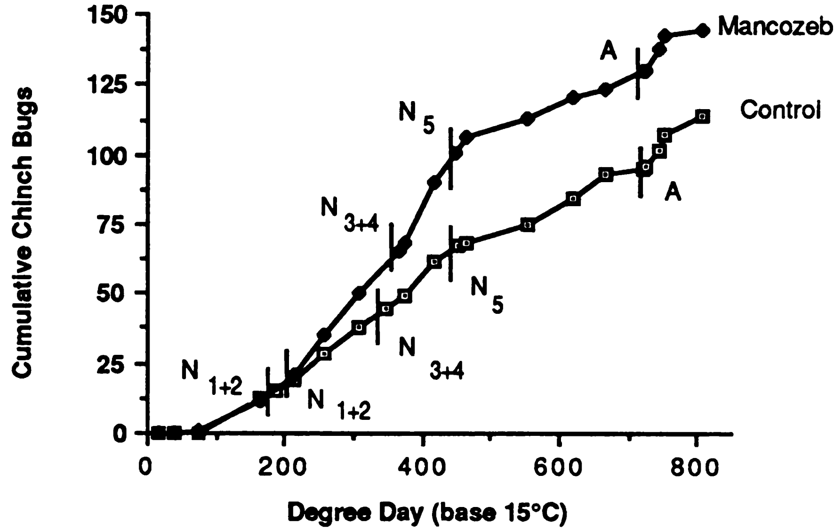

Figure 6. Cumulative number of chinch bugs in control and dithane treated plots in 1987. Data are sums of average number of bugs observed in 6 transects in each of 7 plots. Slopes of lines are significantly different (Control: m=.094, mancozeb: m=.186, t=7.40, df=26, P<0.001). Vertical bars represent peak density of instar groups, determined as the 50% point in the cumulative instar group count. N_{1+2} means the group of nymphal instars 1 and 2, etc, and A stands for adult.

Chinch bug development rate was determined in 1987 by plotting the 50% point of the cumulative count of each of the instar groups for the control and fungicide treated groups. The chinch bugs in the fungicide treated and control plots had similar rates of development in 1987 as evidenced by the similar timing of instar population peaks (Figure 6). The group composed of instars one and two peaked at 186 degree days in the control plots, whereas it peaked at 212 degree days in the fungicide treated plots. The third and fourth instar combined group peaked at 346 degree days days in the control, and 366 degree days in the fungicide treatment. Fifth instars and adults reached maximum population levels at 451 degree days and 724 degree days, respectively, in control plots and 450 degree days and 724 degree days, respectively, in the fungicide treatments.

Symptoms of phytotoxicity were noticed in the treated turf during the middle of July in 1987. This may have been caused by drought conditions. Treated turf was noticeably more yellow than the non-treated turf. Thatch was significantly thicker in treated plots than in the control plots in 1987 (10.32 mm and 3.54 mm, respectively, $t=6.2$, $P<0.001$). Thatch was not measured in 1986.

Sporulation of chinch bugs collected in September of 1986 with the insect pathogenic fungus Beauveria bassiana did not differ between fungicide treated plots and controls. Of insects from fungicide treated plots an average of 8.6% sporulated with Beauveria, compared to 9.2% in control plots. These infection rates are not significantly different ($t= 0.07$, $P>0.50$). No other fungal pathogens were found to sporulate from chinch bugs collected from the field plots. Over the course of the field season, ten out of 228 bugs (4.4%) observed in the control plots sporulated with an undetermined powdery white fungus, compared to 12 out of 356 (3.4%) in the fungicide treated plots.

Dethatching Experiment

There were significantly more chinch bugs found in plots with thatch compared to dethatched plots 24 hrs after release (Table 6, $t=2.47$, $0.02<P<0.05$). The trend remained the same at 72 and 120 hrs after release, although the counts were no longer statistically significantly different (for 72 hrs; $t=1.77$, $0.10<P<0.2$ and for 120 hrs; $t=1.76$, $0.10<P<0.20$).

Predation Experiment

Chinch bug mortality was not correlated with changing densities of big-eyed bugs (Figures 7 and 8). There was 50% mortality of big-eyed bugs during the first experiment, and 90% during the second. Therefore, data are graphed using mean number of live big-eyed bugs during each experiment, determined by adding the number of live bugs at the beginning to the number of live bugs at the end and dividing by two. Mortality of chinch bugs did not increase with increasing big-eyed bug densities in the first experiment (Figure 7). It appeared as though chinch bugs may have had increased survivorship in the thatch treatment as compared to the no thatch treatment; however, neither the slopes nor the intercepts of the lines were significantly different. There was little chinch bug mortality during the second experiment (Figure 8). Big-eyed bugs were observed to feed on chinch bugs in the laboratory, sometimes with more than one big-eyed bug feeding on a single chinch bug. Big-eyed bugs also fed on each other.

Table 6. Mean number of chinch bugs observed in thatched and dethatched turfgrass plots. Variance is reported in parentheses.

Days after release	With thatch	Without thatch
1	6.88 (28.64)	2.12 (0.98)
3	4.88 (6.70)	3.00 (2.29)
5	1.71 (1.71)	0.86 (0.86)

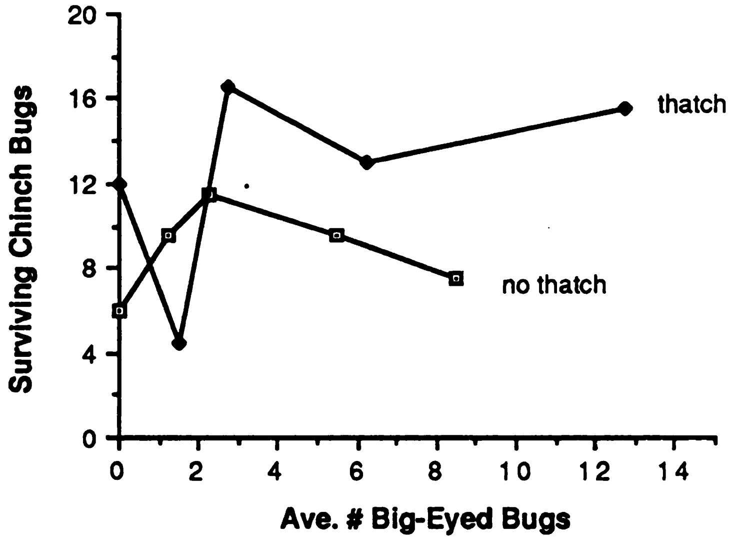

Figure 7. Number of chinch bugs surviving one week confinement with different numbers of big-eyed bugs (BEB), first experiment. Due to mortality of BEB during the experiment, BEB numbers are reported as the average live BEB. Slopes and intercepts of lines are not significantly different (slope of non-thatch treatment =1.41, thatch treatment=1.56, t=1.195, P>.05; for test of intercepts, t=0.322, P>.05)

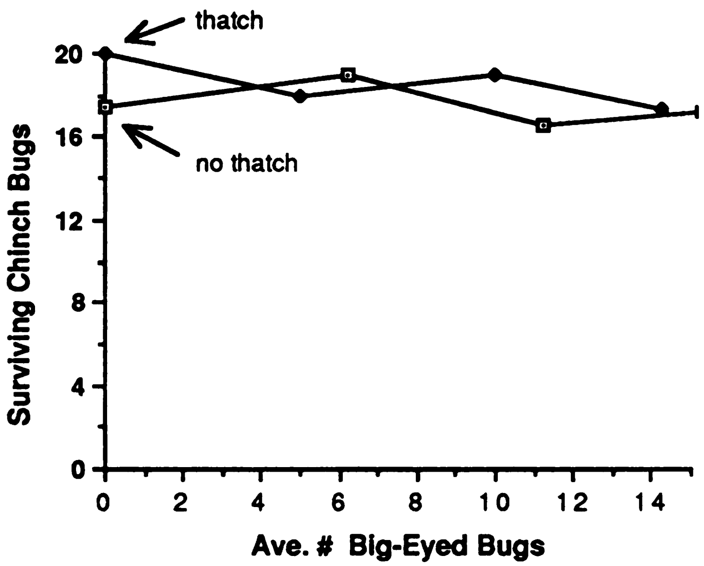

Figure 8. Number of chinch bugs surviving one week confinement with different numbers of big-eyed bugs (BEB), second experiment. Due to mortality of BEB during the experiment, BEB numbers are reported as the average live BEB. Slopes and intercepts are not significantly different.

Survey

Thatch thickness and chinch bug density were significantly positively correlated ($r=0.325$, $n=108$, $P<0.0006$). On lawns for which there were two years of data, I used a paired t-test to compare thatch accumulation for the two years in both infested and non-infested lawns. Thatch significantly increased from 1986 to 1987 in infested lawns (from a mean of 6.5 mm to a mean of 10 mm, $d=-3.55$, $n=25$, $t=-2.73$, $0.01<P<0.02$) but did not significantly change in lawns without chinch bugs (4.0 mm to 5.3 mm, $d=-1.29$, $n=9$, $t=-0.667$, $P>0.5$).

DISCUSSION

Accumulation of thatch is caused by an imbalance in the rate of production and decay of organic matter (Beard, 1973). Many cultural factors are known to contribute to the accumulation of thatch. Some of these are the growth characteristics of the turfgrass cultivar (Shearman et. al, 1980), high nitrogen levels (Potter et al., 1985), acidic conditions of the soil, infrequent or excessively high cutting levels (Beard, 1973; Shearman et al., 1980), failure to remove clippings (Soper, et al., 1988), and treatment with certain herbicides (Turgeon, et al., 1975), insecticides (Streu, 1973) and fungicides (Smiley et al., 1985). Thatched turf is also generally shallow-rooted, making it more susceptible to temperature stress (Dunn et al., 1981).

Chinch bugs were found in larger numbers in lawns that had thick thatch. However, the significant correlation implies only a mathematical relationship, not causality. Chinch bugs may be responding to, or, alternatively, influencing thatch thickness of a lawn. Damage caused to vascular tissues by chinch bug feeding activity may prevent water and nutrients from reaching leaves and shoots, thus killing the plant (Painter, 1928). Baker et al. (1981) found a higher percent dry matter content in turf of chinch bug infested lawns. A significant increase in thatch thickness from 1986 to 1987 was found in chinch bug infested lawns in this study. No such increase was observed in non-infested lawns. One hypothesis worthy of future investigation is that chinch bug feeding injury contributes to accumulation of thatch.

Alternatively, chinch bug populations may be responding to the increase in thatch, not causing it. The fungicide mancozeb is known to increase thatch accumulation by decreasing the degradation of organic material (Smiley et al., 1985). The thick thatch induced by fungicide treatment did not affect the rate of development of chinch bugs in those plots as evidenced by the similar timing of instar population peaks for fungicide and control plots (Figure 6). These peaks differed by a maximum of 87 degree days (base 15°C) from those determined by Mailloux and Streu (1981). Experimentally increasing thatch thickness with low rate mancozeb treatments did, however, increase chinch bug abundance as compared to controls (Figures 5 and 6). Beauveria bassiana activity was monitored in these plots because Beauveria has been observed to infect large numbers of chinch bugs in turfgrass (Bartlett and Lefebvre, 1934; Kennedy, 1981). Although mancozeb is known to be active against Beauveria bassiana (Loria et al., 1983), no differences among treatments were found in the number of dead chinch bugs sporulating with fungus in field plots or in moist chambers in the laboratory. No other fungal pathogens were found to sporulate from chinch bugs collected from field plots. It is possible that mancozeb treatment suppressed predator or parasitoid activity. However, no differences were detected in the number of predators observed in mancozeb compared to control plots, and no

parasitoids emerged from field collected bugs. The difference in chinch bug abundance between mancozeb and control treatments may be owing to either a higher oviposition rate or a lower mortality rate in the mancozeb plots. Direct effects of mancozeb on predators or indirect effects such as protection from predators and/or protection from extremes in temperature and humidity afforded by the thicker thatch may have contributed to reduced chinch bug mortality in these plots.

Chinch bugs are also attracted to thatchy areas. There were significantly more bugs in the thatched compared to the dethatched plots 24 hrs after release of the bugs (Table 6). Because chinch bugs were not confined to our study plots it is possible that the bugs were mostly moving out of all plots into surrounding turf, and the observed differences were due ascribable to longer residence times by chinch bugs in thatched plots.

Possible benefits for chinch bugs living in a thickly thatched environment are not clear. Probabilities of survival may increase in thick thatch by reduced predator efficiency. The big-eyed bug (Geocoris bullatus) is known to be a predator of the chinch bug, and is often found in large numbers in chinch bug infested lawns (Mailloux and Streu, 1981). The large eyes possessed by the big-eyed bug suggest that it relies heavily on vision to find its prey. In a thatchy environment, it may be more difficult for big-eyed bugs to locate chinch bugs because chinch bugs tend to hide in the thatch. The impact that the big-eyed bug has on chinch bug populations has not been determined. Mailloux and Streu (1981) did not find a correlation between chinch bugs and big-eyed bug populations. In our laboratory studies, we observed the big-eyed bug to feed upon the chinch bug, but we did not see a significant effect on adult chinch bug mortality (Figures 7 and 8). Immature chinch bugs were not offered as prey but actually may be the preferred food source. The high

source. The high mortality rate of the big-eyed bug during the second run of the experiment (90% over a one-week period) may have eliminated any potential predation effect on the chinch bugs. More experiments are required to determine whether big-eyed bugs have a significant impact on chinch bug populations in turfgrass.

The results of this study indicate that chinch bug abundance is closely linked to the thatch thickness of home lawns. I have presented and tested several hypotheses for why thatch thickness is related to chinch bug abundance. It may be hypothesized that grass species composition is the driving force affecting chinch bug abundance and that thatch thickness is merely correlated to species composition. However, in Chapter 1 I showed that thatch thickness was not related to species composition of home lawns. Three hypotheses that deserve attention are: 1) thatch helps chinch bugs escape predation; 2) thatch reduces mortality from environmental stress; and 3) chinch bug feeding injury induces thatch.

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Chapter 3

Feeding Preference of Chinch Bug (Blissus leucopterus Hemiptera:Lygaeidae) for Fine Fescue and Kentucky Bluegrass

INTRODUCTION

Feeding preferences of insects may be the primary separation force causing the evolutionary diversity in phytophagous species (Bush 1975; Dethier, 1958). The chinch bug, Blissus leucopterus, has two subspecies, B. l. leucopterus and B. l. hirtus (Leonard, 1966). The two races are separated in geographic range but even more so by host preference. B. l. leucopterus feeds mostly on wheat, sorghum, and corn, while B. l. hirtus feeds primarily on turfgrasses, such as Kentucky bluegrass, fine fescue, and the ryegrasses (Leonard, 1966). Chinch bug preferences for certain host plants have not been shown for B. l. leucopterus (Stuart et al., 1985; Wilde et al., 1986). Ratcliffe (1982) found that B. l. hirtus, the hairy chinch bug, has a preference for certain cultivars of Kentucky bluegrass. However, feeding preference among common home lawn grass species has not been addressed. In this investigation I sought to determine the feeding preference of the hairy chinch bug for two of the most common temperate region home lawn turfgrasses, Kentucky bluegrass (Poa pratensis) and fine fescue (Festuca rubra).

MATERIALS AND METHODS

Standard golf course cup-cutter plugs of "Fylking", "Adelphi", and "Kenblue" Kentucky bluegrass cultivars and "Biljart" and "Jamestown" fine fescue cultivars were taken from the Hancock Turfgrass Research Center on the Michigan State University (East Lansing, MI) campus. These were planted in clay pots in the greenhouse where they received uniform watering and clipping treatment. Because only two cultivars of fine fescue were available at the Hancock Center, a third , "Wintergreen", was planted in the greenhouse one month before the beginning of the test.

Resting Habitat Preference

Resting habitat preferences for B. l. hirtus were tested on July 15 and 16, 1987. Standard cup-cutter plugs of each of the six cultivars were cut into quarters. One quarter of each of the six cultivars was placed on the soil in an 20 cm diameter clay pot, alternating Kentucky bluegrass quarters with fine fescue quarters. Six permutations of cultivar quarters arranged in this fashion were possible. Two replicates of each permutation were produced, for a total of 12 test arenas. The grass in each arena was surrounded by a clear plastic collar, 53 cm in circumference, and 17 cm tall, placed 2 cm into the soil. The area around the turfgrass and collar was covered by white silica sand. Twenty chinch bugs (5 adults, 12 fifth instars and 3 third or fourth instars) were introduced into the center of the arena, and the top of the collar was covered with a piece of parachute cloth secured with elastic banding. One-fifth of the chinch bugs used had been reared from eggs according to the method described by Baker et al. (1981). Because of a low success rate in chinch bug rearing, the rest of the bugs used in the experiment were collected as immatures and maintained on corn stalk sections through at least one moult. After 24 hrs., the arenas were dismantled and the cultivar quarters removed and visually searched for chinch bugs.

Feeding Preference Tests

Feeding preference test chambers were prepared using 90 mm plastic Petri dishes. Five 6mm diameter holes were drilled along the top edge of the Petri dish. The four outer holes were covered with mosquito netting and served to ventilate the chamber. The center hole was fitted with a cork and provided an opening for introduction of the chinch bugs into the chamber. Twenty cc of white silica sand was placed into the bottom of the dish and was wetted with 6 ml of water. One plant of Kentucky bluegrass and one plant of fine fescue were placed in the sand. The lid of the dish was attached by a double layer of Parafilm and the whole chamber gently tapped on one edge to cause the sand to collect in the bottom of the chamber (Figure 9). Completed chambers were stabilized for 24 hrs before introduction of the chinch bugs. Five replicates of each of the nine permutations of cultivar combinations (three cultivars each of the two grass species) were set up, for a total of 45 chambers.

Immature chinch bugs were collected from three heavily infested lawns of varying grass composition in the Lansing, MI area June 30 and July 27, 1988. Bugs were maintained in the lab on corn stalk sections for at least a week before being used in any experiment. On August 5, 1988, a single fifth instar chinch bug was introduced into each chamber. The chambers were kept up-right in a rack and the bugs were observed every fifteen minutes beginning at 8 AM and continuing until 3 PM for a total of 29 observations on each bug. Feeding was recorded as positive when the bug was observed to have its proboscis inserted into the plant. Observations took place under a combination of fluorescent and incandescent light in a lab at 25°C and 80% relative humidity. The experiment was repeated on August 11, 1988 using a new set of test bugs. The difference between the number of feeding observations on Kentucky bluegrass and fine fescue for each chinch bug was determined and used to calculate a t value for comparison in a paired t-test.

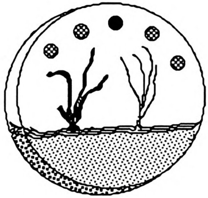

Figure 9. Choice chamber used in feeding preference test. The chamber consisted of a modified 90 mm plastic Petri dish. One fine fescue and one Kentucky bluegrass plant were held upright in moist white silica sand.

RESULTS

Two hundred and one of the 240 chinch bugs introduced into the resting habitat preference arenas were recovered. Of these, 113 were found in Kentucky bluegrass plug quarters and 88 were found in fine fescue plug quarters. Given an expected ratio of 50% of the bugs in each of the two turf types, a log likelihood ratio test value of 3.12 ($0.05<P<0.10$) was found. Although the value was not significant at the .05 level, there was some indication that the chinch bugs were preferentially resting in the Kentucky bluegrass sections.

Of the 90 chinch bugs observed in the feeding preference experiments, 54 fed only on Kentucky bluegrass, 7 fed only on fine fescue, 22 fed on both, and 7 did not feed. Subtracting the number of observations of feeding on fine fescue from the number of observations of feeding on Kentucky bluegrass for each bug yielded differences (D 's) for the two replicates of the experiment of 5.98 and 9.05, with variances of 101.87 and 105.2, respectively. These translate into paired t-test values of 3.79 and 3.54 (df=41), which are both significant at $P<0.001$. Chinch bugs fed significantly more on Kentucky bluegrass than on fine fescue plants.

DISCUSSION

This study indicates that Blissus leucopterus hirtus prefer to feed on Kentucky bluegrass over fine fescue. Several limitations of this experiment that could affect the results should be pointed out. First, stress to grass plants during set-up of the choice chambers may have affected plant palatability (Risch, 1985). The chinch bugs may feed as early instars on the fine blades of fine fescue. Second, field collected chinch bugs could have had food plant preferences imprinted during the early instars that affected their choice in these experiments even after being held on corn plants for at least seven days prior to the experiment. In a previous study Davis and Smitley (in prep.) found that chinch bugs are most typically found in lawns with a moderate percentage of fine fescue and a significantly lower percentage of Kentucky bluegrass as compared to lawns without chinch bugs. Yet, our feeding preference study suggests they prefer to feed on Kentucky bluegrass. At least three hypotheses could explain this apparent discrepancy between feeding preference and observed habitat. Chinch bugs could be causing higher mortality to the Kentucky bluegrass in mixed Kentucky bluegrass/fine fescue lawns, reducing the proportion of Kentucky bluegrass present. The presence of fine fescue may favor chinch bug survival, even though it is not a preferred food plant. Given that some chinch bug infested lawns were composed entirely of fine fescue, this plant had served as a food plant. Third, something in the laboratory experiment was different enough from natural conditions such that the bugs behaved atypically. Although host preferences are not always correlated with host suitability, discrimination between host plants is expected to evolve toward a maximization of encounter rate, oviposition probability, and host suitability (Rausher, 1983). Studies on the development and oviposition of the chinch bug on these host plants under laboratory and field conditions are necessary to more completely understand the importance of these two grasses in hairy chinch bug ecology.

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SUMMARY

This research has shown that chinch bug presence and abundance in a lawn is related to the thickness of the thatch and species composition of the turf. Surveys of parameters of the chinch bug (Blissus leucopterus) turfgrass environment examined over a three year period in a 108 home lawns in the greater Lansing Michigan area showed thatch thickness to be the only variable correlated to chinch bug abundance in all three years. It is not clear whether chinch bugs are responding to thatch thickness, contributing to thatch thickness, or whether thatch thickness and chinch bug abundance are both affected by a third variable that was not accounted for in this study. The fact that thatch became thicker over a two year period in chinch bug infested lawns but did not change in non-infested ones may mean that chinch bugs are contributing to thatch thickness. Increases in chinch bug populations in research plots in which thatch development was induced by repeated fungicide applications leads me to believe that thick thatch imparts some benefit to survival or reproduction of chinch bugs. Chinch bugs that were released into areas with thatch and areas that were dethatched appeared to have at least a short-term habitat preference for turf with thatch. Predation pressure on chinch bug populations may be lower in turf with thick thatch. Big-eyed bugs (Geocoris bullatus) fed on adult chinch bugs in the laboratory, but confinement with big-eyed bugs did not significantly affect chinch bug population sizes in the laboratory.

There was significantly more fine fescue (Festuca rubra) and less Kentucky bluegrass (Poa pratensis) in chinch bug infested lawns as compared to non-infested lawns. When tested in the laboratory, chinch bugs were found to feed more on Kentucky bluegrass than on fine fescue. There was a tendency for chinch bugs to hide in Kentucky bluegrass preferentially over fine fescue, although the difference was not significant. This is contrary to findings that showed chinch bugs were most often found in lawns with a higher fine fescue and lower Kentucky bluegrass content compared to lawns that did not have chinch bugs. This discrepancy may be explained by feeding preferences of chinch bugs for Kentucky bluegrass causing differential mortality of the Kentucky bluegrass in infested lawns, thus reducing the relative proportion of Kentucky bluegrass. Further investigation of why lawns with chinch bugs differ in composition from lawns without would be useful.

Relatively good Discrimination between chinch bug habitat and chinch bug non-habitat was given by a discriminant function determined from 1986 thatch thickness and percent Kentucky bluegrass data. When tested with 1986, 1987, and 1988 data the function correctly predicted chinch bug presence or absence in a lawn in from 63% to 81% of cases. Although the relationship between chinch bug presence and these two variables can only be said to be correlative and not cause and effect, the results of the discriminant function indicate a direction for future research. The discriminant function may also have practical application as an aid in turf management decisions regarding preventative treatment or monitoring for chinch bugs.

APPENDICES

APPENDIX 1

Record of Deposition of Voucher Specimens*

The specimens listed on the following sheet(s) have been deposited in the named museum(s) as samples of those species or other taxa which were used in this research. Voucher recognition labels bearing the Voucher No. have been attached or included in fluid-preserved specimens.

Voucher No.: 1989-7

Title of thesis or dissertation (or other research projects):

The Relationship of Chinch Bug (Blissus leucopterus Hemiptera: Lygaeidae Presence and Abundance to Parameters of the Turfgrass Environment

Museum(s) where deposited and abbreviations for table on following sheets:

Entomology Museum, Michigan State University (MSU)

Other Museums:

Investigator's Name (s) (typed)

Maria Geraldine Davis

Date August 3, 1989

*Reference: Yoshimoto, C. M. 1978. Voucher Specimens for Entomology in North America. Bull. Entomol. Soc. Amer. 24:141-42.

Deposit as follows:

Original: Include as Appendix 1 in ribbon copy of thesis or dissertation.
Copies: Included as Appendix 1 in copies of thesis or dissertation.
Museum(s) files.
Research project files.

This form is available from and the Voucher No. is assigned by the Curator, Michigan State University Entomology Museum.

APPENDIX 1.1

Voucher Specimen Data

Page 1 of 1 Pages

Species or other taxon	Label data for specimens collected or used and deposited	Number of: Eggs	Larvae	Nymphs	Pupae	Adults ♀	Adults ♂	Other	Museum where deposited
Blissus leucopterus Montandon	Michigan: Okemos Ingham Co. 10 June 1988					6	6		
Blissus leucopterus Montandon	Michigan: E. Lansing Ingham Co. 20 June 1988			20					
Blissus leucopterus Montandon	Michigan: E. Lansing Ingham Co. 20 July 1989			5					
Geocoris bullatus (Say)	Michigan: E. Lansing Ingham Co. 20 June 1988					6	6		

(Use additional sheets if necessary)

Investigator's Name(s) (typed)
Maria Geraldine Davis

Date ~~August 3 1989~~

Voucher No. 1989-7
Received the above listed specimens for deposit in the Michigan State University Entomology Museum.

Curator

Date July 20, 1989