1988

Studies on the Seasonal Biology, Influence of Temperature on Immature Stages, and Damage to Field Corn by the Chinch Bug, Blissus Leucopterus Leucopterus (Say).

Jose Fermin Negron-segarra

*Louisiana State University and Agricultural & Mechanical College*

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Studies on the seasonal biology, influence of temperature on immature stages, and damage to field corn by the chinch bug, *Blissus leucopterus leucopterus* (Say)

Negron-Segarra, Jose Fermin, Ph.D.

The Louisiana State University and Agricultural and Mechanical Col., 1988
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UMI
STUDIES ON THE SEASONAL BIOLOGY,
INFLUENCE OF TEMPERATURE ON IMMATURE STAGES,
AND DAMAGE TO FIELD CORN BY THE CHINCH BUG,
BLISSUS LEUCOPTERUS LEUCOPTERUS (SAY)

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor in Philosophy

in

The Department of Entomology

by

Jose F. Negron-Segarra
B.S., University of Puerto Rico at Mayaguez, 1982
M.S., Louisiana State University, 1984
May, 1988
ACKNOWLEDGEMENTS

The author wishes to express his utmost appreciation to Dr. Thomas J. Riley for his guidance, support, and friendship throughout this study and my years of graduate training at Louisiana State University. Gratitude is also extended to Dr. E. A. Heinrichs, Dr. S. S. Quisenberry, and Dr. R. N. Story in the Department of Entomology; Dr. L. E. Urbatsch in the Department of Botany; and Dr. M. Amacher in the Department of Agronomy for serving in my advisory committee and for their suggestions in the preparation of this dissertation.

The invaluable help of various student workers who at one point or another made significant contributions to this work is also appreciated. These were: U. Blas, M. Cush, K. Gautreaux, S. Guidry, and A. Ohmstede. I would also like to acknowledge the support staff in the Department of Entomology both at the departmental office and at the St. Gabriel Research Station for their help in various phases of this work.

Finally a special gratitude is extended to my wife, Miriam, my little girl, Astrid Camila, my parents, and to all my friends at L.S.U. who have provided understanding and support and have made the hard times enjoyable and gratifying.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>ii</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>iii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>viii</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>LITERATURE REVIEW</td>
<td>3</td>
</tr>
<tr>
<td>REFERENCES CITED</td>
<td>7</td>
</tr>
</tbody>
</table>

## CHAPTER I

Seasonal Biology of the Chinch bug (Heteroptera: Lygaeidae) in Louisiana

- **Abstract** ................................................... 11
- **Introduction** ............................................... 12
- **Materials and Methods** ................................... 13
- **Results and Discussion** .................................. 16
- **References Cited** ........................................... 34

## CHAPTER II

Influence of Temperature on the Immature Stages of the Chinch Bug (Heteroptera: Lygaeidae)

- **Abstract** ................................................... 36
- **Introduction** ............................................... 37
- **Materials and Methods** ................................... 38
- **Results and Discussion** .................................. 39
- **References Cited** ........................................... 49
# TABLE OF CONTENTS (Continued)

<table>
<thead>
<tr>
<th>CHAPTER III</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of Chinch bug (Heteroptera: Lygaeidae) Feeding in Seedling Corn</td>
<td>51</td>
</tr>
<tr>
<td>Abstract</td>
<td>52</td>
</tr>
<tr>
<td>Introduction</td>
<td>53</td>
</tr>
<tr>
<td>Materials and Methods</td>
<td>53</td>
</tr>
<tr>
<td>Results and Discussion</td>
<td>55</td>
</tr>
<tr>
<td>References Cited</td>
<td>61</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER IV</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longterm Effects of Chinch Bug (Heteroptera: Lygaeidae) Feeding in Corn</td>
<td>62</td>
</tr>
<tr>
<td>Abstract</td>
<td>63</td>
</tr>
<tr>
<td>Introduction</td>
<td>64</td>
</tr>
<tr>
<td>Materials and Methods</td>
<td>64</td>
</tr>
<tr>
<td>Results</td>
<td>67</td>
</tr>
<tr>
<td>Discussion</td>
<td>71</td>
</tr>
<tr>
<td>References Cited</td>
<td>77</td>
</tr>
</tbody>
</table>

CONCLUDING REMARKS | 78 |

BIBLIOGRAPHY | 80 |

VITA | 84 |
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAPTER II Influence of Temperature on the Immature Stages of the Chinch Bug (Heteroptera: Lygaeidae).</td>
<td></td>
</tr>
<tr>
<td>1. Mean (SEM) duration (days) of immature stages of <em>B. l. leucopterus</em> at two temperature regimes and a 14:10 (L:D) photoperiod</td>
<td>40</td>
</tr>
<tr>
<td>2. Mean (SEM) total developmental time (days) for <em>B. l. leucopterus</em> males and females at two temperature regimes and a 14:10 (L:D) photoperiod</td>
<td>41</td>
</tr>
<tr>
<td>CHAPTER III Effect of Chinch Bug (Heteroptera: Lygaeidae) Feeding in Seedling Corn.</td>
<td></td>
</tr>
<tr>
<td>1. Mean heights (cm) of corn seedlings, infested at the V1, V2, and V2.5 stages of plant development with <em>B. l. leucopterus</em> at the date of insect removal, 1 week, and two weeks after insect removal</td>
<td>56</td>
</tr>
<tr>
<td>CHAPTER IV Longterm Effects of Chinch Bug (Heteroptera: Lygaeidae) Feeding in Corn.</td>
<td></td>
</tr>
<tr>
<td>1. Effect of <em>B. l. leucopterus</em> infestation level and plant stage main effects on ear weight (g) and ear length (cm), 1986</td>
<td>68</td>
</tr>
<tr>
<td>2. Corn plant height at 1, 8, and 15 days post-infestation, ear weight (g), and ear length (cm) of plants infested at the V2 stage of development with <em>B. l. leucopterus</em>, 1986</td>
<td>69</td>
</tr>
<tr>
<td>3. Corn plant height at 1 and 7 days post-infestation, ear weight (g), and ear length (cm) of plants infested at the V5 stage of development with <em>B. l. leucopterus</em>, 1986</td>
<td>70</td>
</tr>
<tr>
<td>4. Corn plant height at 1, 9, and 17 days post-infestation, ear weight (g), and ear length (cm) of plants infested at the V2 stage of development with <em>B. l. leucopterus</em>, 1987</td>
<td>72</td>
</tr>
</tbody>
</table>
5. Corn plant height at 5 and 8 days post-infestation, ear weight (g), and ear length (cm) of plants infested at the V5 stage of development with _B. l. leucopterus_, 1987 ........................................ 73

6. Ear weight (g) and ear length (cm) for plants damaged by _B. l. leucopterus_ and rated in four damage classes, 1987...................... 74
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHAPTER I</strong> Seasonal Biology of the Chinch Bug (Heteroptera: Lygaeidae) in Louisiana</td>
<td></td>
</tr>
<tr>
<td>1. Mean number of chinch bugs/trap/day collected in flight traps in corn and maximum daily temperature oscillations, Spring 1985</td>
<td>19</td>
</tr>
<tr>
<td>2. Mean number of chinch bugs/trap/day collected in flight traps in corn and wheat and maximum daily temperature oscillations, Spring 1986</td>
<td>21</td>
</tr>
<tr>
<td>3. Mean number of chinch bugs/trap/day collected in flight traps in corn and maximum daily temperature oscillations, Spring 1987</td>
<td>23</td>
</tr>
<tr>
<td>4. Mean number of chinch bugs/trap/day collected in flight traps in A. virginicus and maximum daily temperature oscillations, Spring 1987</td>
<td>25</td>
</tr>
<tr>
<td>5. Abundance of overwintering chinch bugs/A. virginicus clump collected in two sites, 1985-86; (A) Site 1. (B) Site 2</td>
<td>28</td>
</tr>
<tr>
<td>6. Abundance of overwintering chinch bugs/A. virginicus clump collected in three sites, 1986-87; (A) Site 1. (B) Site 2. (C) Site 3</td>
<td>30</td>
</tr>
<tr>
<td><strong>CHAPTER II</strong> Influence of Temperature on the Immature Stages of the Chinch Bug (Heteroptera: Lygaeidae).</td>
<td></td>
</tr>
<tr>
<td>1. Total number of B. 1. leucopterus eggs hatching and their incubation period (days) at 28°C and a 14:10 (L:D) photoperiod</td>
<td>45</td>
</tr>
<tr>
<td>2. Total number of B. 1. leucopterus eggs hatching and their incubation period (days) at 22°C and a 14:10 (L:D) photoperiod</td>
<td>47</td>
</tr>
</tbody>
</table>
Seasonal biology studies of the chinch bug, Blissus leucopterus leucopterus (Say), indicated movement out of overwintering sites in April in central Louisiana. Mass emergence appeared to be influenced by ambient temperatures of 26.7°C or above. Overwintering populations attacked corn and wheat simultaneously and field invasions were predominantly by flight. Peak overwintering populations in Andropogon virginicus L. occurred in November and December. Overwintering populations decreased consistently beginning in January and culminated with spring emergence. Fall migrations back to overwintering sites began in September and peaked in October.

Studies on the effect of temperature on the immature stages of this insect indicated faster development at 28°C than at 22°C. Males developed significantly faster than females at 22°C but not at 22°C. First and fifth stadia were the longest in duration for both males and females and at both temperatures. Egg survival was not affected by temperature; however, incubation period was shorter at 28°C when compared to 22°C.

Greenhouse studies were conducted in which corn seedlings were infested at different stages of plant development with varying levels of chinch bug density. Results indicated a highly significant interaction between plant developmental stage and chinch bug infestation level. This suggests that the response of corn seedlings to chinch bug infestations is dependent on the stage of plant development. Persistent reductions in plant height were obtained two weeks after insect pressure was removed from the plants with 10
insects/plant for V1 plants, 15 insects/plant for V2 plants, and 20 insects/plant for V2.5 plants.

Field studies were conducted in an effort to determine the long-term effect of chinch bug feeding in seedling corn. Corn plants were infested artificially at two stages of plant development with different chinch bug densities. In addition, plants damaged by a natural chinch bug infestation were rated into no damage, slight, moderate, and heavy damage classes at the time of damage and followed to maturity. Results indicated that young plants were most susceptible to damage and reduced performance of plants was evident with slight or greater levels of damage.
INTRODUCTION

In the early decades of the 1900's, the chinch bug, *Blissus leucopeterus leucopeterus* (Say), was one of the most destructive native insects attacking grain and grasses in the United States (Flint & Larrimer 1926). Pecuniary losses caused by chinch bugs at the time were in the hundreds of thousands of dollars (Metcalf at al. 1962). Recently, increases in chinch bug infestations have been reported from various states and the northern part of Louisiana.

Information about the life history of this insect and how it relates to corn is available; however, most of this information is not recent and was obtained from areas in the mid-western United States. Since cropping systems and weather patterns are different in the south, differences in seasonal biology can be expected and need to be investigated. Aside from observations on the overwintering habits of chinch bugs, little quantitative data is available and none has been obtained from the south. More biological information of the chinch bug is still needed to augment our knowledge and understanding of this insect.

Chinch bugs cause damage to plants by withdrawing plant juices from the plant base. Their feeding can result in wilting, stunting, and in the case of severe infestations, death of the plants. Various factors such as the age of the plant, number of insects per plant, duration of feeding, and environmental conditions in which the plant is growing will determine the extent of damage to plants. Little information relating the number of chinch bugs to mortality, or damage, or both, to seedling corn is available on which to base accurate management practices.
The objectives of the work presented here were: 1) to study the overwintering habits and temporal movement of the chinch bug in Louisiana, 2) to determine egg incubation periods and nymphal developmental times in the laboratory and compare it to that of other species of the genus *Blissus*, and 3) to conduct injury level studies to obtain base data on which to base adequate control measures for chinch bugs in corn.
LITERATURE REVIEW

The chinch bug was originally described as *Blissus leucopterus* (Say) in 1831. The present combination of *Blissus leucopterus leucopterus* (Say) was made by Leonard (1966) in his revision of the "leucopterus" complex; however, according to Leonard (1966) the first observation of damage to agriculture by this insect dates back to the 1870's in North Carolina where it was reported to be damaging wheat. In the late 1800's and early 1900's, the chinch bug was one of the most damaging insects in grass crops in the United States (Flint & Larrimer 1926). Economic losses caused by this insect during the turn of the century were estimated in the hundreds of thousands of dollars (Metcalf et al. 1962).

Throughout history, chinch bug infestations have been periodical in nature, outbreaks usually lasting for only a few years. Many authors have attributed this phenomenon to weather patterns, chinch bug infestations being more devastating after a few years of subnormal precipitation. No data indicating weather as a causal agent for chinch bug outbreaks have been collected, but circumstancial evidence seems to support this idea. Shelford & Flint (1943) correlated chinch bug populations in Illinois and surrounding areas with weather patterns from 1823 to 1940. Their study indicated that below normal rainfall in August, September, and October often yielded large overwintering populations and that damaging populations were often associated with growing seasons with above normal temperatures and subnormal rainfall.

**Life History.** Various authorities, including works by Headlee & McColloch (1913), Webster (1915), and Flint & Larrimer (1926)
described the life history of the chinch bug in the mid-western United States. A summary of these descriptions is presented in Chapter I. Luginbill (1922) described the life history of this insect in South Carolina. His work did not include crop phenology but did include thorough experimentation on biological parameters such as oviposition, egg incubation period, and development. More recently, Smith et al. (1981) studied oviposition, longevity, and rate of development in different host plants along with the effects of photoperiod.

**Type of Damage.** As far as has been reported, species in the genus *Blissus* feed only on plants of the grass family (Leonard 1966). *B. l. leucopterus* has been the species in the genus associated with damage to agricultural grain crops. Chinch bugs cause damage by feeding at the base of the plant behind the leaf sheaths or at the soil level. They penetrate the plant with their piercing-sucking mouthparts and extract sap from the plant. Damage usually begins to show as wilting and drying of the plants (Metcalf et al. 1962). Under severe infestations total destruction of small grains and cornfields has occurred (Headlee & McColloch 1913, Webster 1915, Flint & Larrimer 1926, Metcalf et al. 1962). More recently Wilde & Morgan (1978) indicated that 30 adult chinch bugs/plant killed 75-125 mm sorghum seedlings in 6-7 days and that fewer bugs caused severe damage depending on plant size. Ahmad et al. (1984) also worked with sorghum and suggested that plants subjected to chinch bug attack and exhibiting symptoms of damage early in their development may not produce normal yields. Negron & Riley (1985) showed persistent reductions in plant height in seedling corn infested with chinch bugs.
for 7 days, 2 weeks after insect pressure was removed from the plants. Insect levels of 10, 15, and 20 insects/plant caused height reductions in plants infested at the V1, V2, and V2.5 stages of development, respectively. No data is presently available regarding the longterm effects of chinch bug damage on corn plant performance.

Control Methods. Flint & Larrimer (1926) and Headlee & McColloch (1913) summarize chinch bug control methods that were effective in the early 1900's. Three methods were recommended at the time: 1) winter burning of bunch grasses harboring overwintering populations of chinch bugs, 2) growing crops that were not attacked by chinch bugs, and 3) the use of barriers, sprays, and dusts at the time of small grain harvest in an attempt to kill the chinch bugs as they moved into corn and sorghum fields. Webster (1915) also suggested the use of a trap crop in the spring to catch chinch bugs as they emerged from overwintering and then plowing the field.

During the mid-1900's, with the advent of synthetic pesticides control strategies for chinch bugs started relying on these compounds. Gannon and Decker (1955) found that parathion, lindane, dieldrin, and aldrin were effective against chinch bugs with the latter two being particularly effective as barrier treatments and having longer residual effects. Toxaphene was effective under certain circumstances and heptachlor, chlordane, and DDT were ineffective. Randolph and Newton (1959) found toxaphene to be very effective for chinch bug control in sorghum.

Later restrictions on some of the effective compounds used for chinch bug control caused agriculturists to search for other compounds. Some insecticidal control studies that have been
conducted recently include works in wheat, corn, and sorghum in Nebraska (Peters 1979, 1983), in sorghum in Kansas (Wilde & Morgan 1978; Mize et al. 1980; Wilde et al. 1984), and in corn in Louisiana (Riley & Skias 1982). This has resulted in a wide variety of compounds that are presently available for chinch bug control in various crops.

The use of host plant resistance as a strategy to reduce the deleterious effects of chinch bug infestations has been considered and continues to be researched. This has been particularly true for sorghum. Snelling et al. (1937) identified varieties with resistance to chinch bugs. Their work led to the release of chinch bug resistant varieties to growers (Dahms & Sieglinger 1954). Additional varieties were screened for chinch bug resistance by Dahms & Sieglinger (1954). Recently Mize & Wilde (1986, 1986a, 1986b) conducted extensive research on new sources for antibiosis for the chinch bug in sorghum. Some reports of resistance in corn to chinch bugs have been published by Flint (1921), Flint & Larrimer (1926), and Painter et al. (1935) and in wheat by Jones (1937) and more recently by Stuart et al. (1985).
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chinch bug (Heteroptera: Lygaeidae) in grain sorghum: contribution of tolerance and antixenosis as resistance mechanisms. J. Econ. Entomol. 79: 42-45.


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CHAPTER I

Seasonal Biology of the Chinch Bug
(Heteroptera: Lygaeidae)
in Louisiana
Abstract

The seasonal biology of the chinch bug, *Blissus leucopterus leucopterus* (Say) was studied in Louisiana from 1985 to 1987. Temporal movement studies indicated that chinch bugs emerge from overwintering sites in March and April and that mass emergences seem to be influenced by ambient temperatures. Corn, *Zea mays* L., and wheat, *Triticum aestivum* L., are attacked simultaneously by overwintering chinch bugs. Sampling of overwintering populations in *Andropogon virginicus* L. indicated peak populations in November and December. Population levels decreased consistently beginning in January and culminated with spring emergence in March.
Introduction

THE LIFE HISTORY of the chinch bug, Blissus leucopterus leucopterus (Say), is largely based on information from the mid-western United States. Some of the more thorough descriptions include works by Headlee & McColloch (1913) and Webster (1915) in Kansas, and Flint & Larrimer (1926) in Illinois. These researchers found that chinch bugs spend the winter as adults using mainly bunch grasses as Andropogon spp. as overwintering hosts. They fly from their overwintering habitats in the spring and attack small grain fields such as wheat, Triticum aestivum L., and barley, Hordeum vulgare L. Here the chinch bugs begin feeding, mating, and laying eggs at the base of the plants. After the eggs of the first generation hatch the crop is usually cut. The developing nymphs are then forced to move on the ground to adjacent seedling corn, Zea mays L., and sorghum, Sorghum bicolor (L.) Moench. This first generation was responsible for the hundreds of thousands of dollars in losses in the early 1900's. When the first generation reaches adulthood they remain in the same field and lay eggs for a second generation. The adults from the second generation fly back to overwintering sites in September and October.

Cropping patterns and agricultural practices have changed considerably since the days that the chinch bug was a major threat to grain production. Moreover, in the South, weather patterns are different from those in the Mid-west. Therefore, differences in the seasonal biology of the chinch bug as it relates to agricultural production can be expected and need to be investigated. The need for this information is becoming increasingly evident considering the
chinch bug outbreaks in recent years which have resulted in the need for control.

The only quantitative data pertaining to the overwintering biology of the chinch bug is a study by Lamp & Holtzer (1980) in Nebraska in which they found that increasing numbers of insects could be found with increasing above-ground biomass in overwintering grass host plants. The objectives of the study presented here were to determine the origin of chinch bug infestations in corn, to determine the timing of the spring and fall migrations of the chinch bug, and to collect data on the overwintering biology of this insect in Louisiana.

Materials and Methods

Temporal Movement. Pitfall and flight traps were used to determine times of chinch bug emergence in the spring and their movement into corn and wheat fields. Pitfall traps consisted of 0.5-liter plastic cups buried in the soil with the top at ground level and with ca. 30.5 cm of plastic garden fencing on both sides of the trap in order to increase the effective area covered by the trap. The cups contained ethylene glycol (Prestone® Antifreeze) as a killing and preserving fluid. Flight traps consisted of 5.1 X 5.1 X 122 cm stakes placed on the ground and a 3.78-liter paper can stapled to the top to which a film of Stick-em® was applied with a paint brush. All traps were checked ca. once a week. Pitfall trap contents were collected and brought to the laboratory for processing. The flight traps were inspected visually, bugs removed, and new Stick-em® placed on the trap or the paper cans replaced as needed.

The study sites were located on Franklin Parish, La. During
1985, 20 traps of each type were placed around a recently planted corn field in Franklin Pa., La., on 29 March. A survey of the area at the time indicated that chinch bugs were abundant in overwintering habitats and absent in available spring host plants in the study areas. For the 1986 season, both a corn field and two wheat fields were sampled but only flight traps were employed to monitor chinch bug movement. Ten traps were placed around each of the wheat fields and 15 around the corn field prior to chinch bug emergence on 5 March. Since similar trap catch trends were observed in both wheat fields the data were pooled. In 1987, the design of the flight trap was changed by using a 0.5-liter yellow plastic cup instead of a paper can. Ten and 17 traps were placed around each of two corn fields. Due to unusually high precipitation during the spring of 1987, corn planting in the study areas was delayed. Consequently, traps around corn fields were not set out until 13 April. Again, since similar trap catch trends were observed, the data from the corn fields were pooled. A total of 23 traps were used to monitor movement out of and into overwintering sites in the spring and in the fall, respectively. These traps were set on 23 February.

Overwintering sites were along roadsides with dense stands of Andropogon virginicus L. where a high density of chinch bugs had been found. Movement back to overwintering sites was also monitored at the Idlewild Research Station in East Feliciana Parish. Twenty flight traps were set out along a forest edge where A. virginicus was abundant.

Flight trap catches were expressed in terms of bugs/trap/day. This allowed for comparable values in situations of different numbers
of traps or uneven intervals between sampling dates, or both.

Overwintering. Populations were monitored during the winter of 1985-86 and 1986-87. A preliminary survey of various grasses indicated that *A. virginicus* was the preferred overwintering host for the chinch bug in central Louisiana (Negron and Riley, unpublished data). Clumps of *A. virginicus* were collected ca. every two weeks from two sites in 1985-86 and three sites in 1986-87 beginning in late October to November and ending in March to April. A total of five clumps from each site were collected every sampling date by digging the clump up with a shovel and placing it in a plastic bag. Samples were processed in the laboratory by shaking the clumps vigorously to dislodge as many bugs as possible. Clumps were then allowed to dry for 1-2 days under an incandescent light in a Berlese funnel and the remaining chinch bugs removed by hand searching through the grass clump again. Insects were counted and data recorded in order to determine the relative size of the overwintering population. During 1985-86 the sex ratio of the overwintering population was determined. Estimates of survival of the overwintering population were expressed as the ratio of the number of chinch bugs/clump collected ca. 1 month prior to peak emergence to the largest number of chinch bugs found during the entire sampling period. Any decreases in the population before spring emergence from overwintering sites were assumed to be due to natural mortality factors.

All sites during both years were located in Franklin Parish, La. Site 1 was along a roadside and ca. 1 km from corn and sorghum fields. Site 2 was also along a roadside, adjacent to a drainage
ditch, and across from a cotton field. No corn or sorghum was grown in close proximity to this site. Site 3 was located on a sloping hillside along the edge of a corn field. Corn, sorghum, and cotton were all being grown approximately 0.5 km from the area.

Results and Discussion

Temporal Movement. During the spring of 1985, traps were checked on 3, 11, 18, 25 April, and 3 May. Trap catches in pitfall traps for each sampling date were 0, 1, 2, 4, and 0, respectively, for a total of 7. In flight traps, catches were 2, 13, 58, 16, and 3, respectively, totaling 92. There was a large difference in the number of chinch bugs caught in flight traps when compared to pitfall traps. These data show that chinch bugs are primarily flying into corn fields in Louisiana in the spring as opposed to movement on the ground as was reported in the mid-western states (Headlee & McColloch 1913, Webster 1915, Flint & Larrimer 1926).

Sampling dates during 1986 were on 17, 27 March, 3, and 16 April. The mean number of chinch bugs/trap/day in each of the sampling dates in the wheat fields was: 0.05, 0.14, 1.26, and 0.36, respectively. In the corn fields, however, the values were: 0.22, 1.47, 14.34, and 1.26. These data indicate that chinch bugs invade corn and wheat fields simultaneously, with higher populations attacking corn. A variety of grasses that are available in the spring are also attacked as indicated by a survey of spring grasses present in the study areas, suggesting a three-way split of the overwintering population into corn, wheat, and diversity of non-crop grasses.

Precipitation during the spring of 1987 was above normal.
Flight traps along overwintering habitats caught chinch bugs beginning on 13 March. The traps around the corn fields were checked for the first time on 22 April, which resulted in the sampling date with the highest number of bugs/trap/day in both the corn and the Andropogon flight traps.

Presented in Figures 1-4 are the number of chinch bugs/trap/day for each year and oscillations in maximum daily temperatures for the sampling periods. From these data, it can be seen that peak emergences occurred on ca. 18 April 1985, 3 April 1986, and 22 April 1987. For all three years, these dates coincided with the rising of maximum daily temperatures to the 26 to 27 °C-level or above. Spring temperatures appear to have a strong influence on the time of emergence of chinch bugs from their overwintering sites and their spring flight into agricultural areas.

Sampling dates for the fall of 1987 in Franklin Parish were on 12, 23, 28 September, 4, 11, 18, 25 October, 1, 8, 15, 29 November, and 5 December. The mean number of bugs/trap/day collected at these dates were: 0, 0.06, 0.05, 0.3, 1, 2.45, 1.07, 0.89, 0.86, 0, 0.03, and 0, respectively. The sampling dates at the East Feliciana site were on 17, 24 September, 1, 7, 14, 21, 28 October, 4, 11, 20, 25 November, and 2 December. The mean number of bugs/trap/day collected at these dates were: 0, 0.08, 0.45, 0.48, 3.05, 3.62, 0.3, 1.38, 0.42, 0.01, 0.02, and 0. Chinch bugs started flying back to overwintering sites beginning in September; however, the majority of the chinch bugs moved during October and peaked on 18 October in Franklin Parish and October 21 in East Feliciana Parish, then they tapered off in November. This is the same pattern for fall
Figure 1. Mean number of chinch bugs/trap/day collected in flight traps in corn and maximum daily temperature oscillations, Spring 1985.
Figure 2. Mean number of chinch bugs/trap/day collected in flight traps in corn and wheat and maximum daily temperature oscillations, Spring 1986.
Figure 3. Mean number of chinch bugs/trap/day collected in flight traps in corn and maximum daily temperature oscillations, Spring 1987.
Figure 4. Mean number of chinch bugs/trap/day collected in flight traps in *Andropogon virginicus* and maximum daily temperature oscillations, Spring 1987.
Maximum Daily Temperature (°C.)

- - - TEMP.
- - - B/T/D

Date

March 31 April 30 May 30

No. of Bugs/Trap/Day

Temperature and insect population trends over March and April.
migrations of chinch bugs described by Headlee & McColloch (1913) in Kansas and Flint & Larrimer (1926) in Illinois.

Overwintering. Season averages (SEM) for the populations at the different localities during 1985-86 were 156.6 (27.1) for Site 1 and 25 (2.7) for Site 2. There was a large difference in the population levels found between the 2 sites. For Site 1, which had the highest levels of chinch bugs, the population peaked on 7 November with 354.7 chinch bugs/Andropogon clump (Figure 5). Thereafter the population decreased consistently throughout the sampling period with the exception of 19 November. The population also peaked on 7 November with 53.7 chinch bugs/Andropogon clump for Site 2. This was only ca. 15% of the number of chinch bugs/clump found in Site 1 at the same date. Thereafter, the population decreased slightly during the next sampling date and then remained at ca. the same levels until 17 March when the next noticeable decrease in the population was observed. Of the insects collected during 1985-86, 49.9 % were females and 50.1 % were males, indicating that the sex ratio of the overwintering population is 1:1.

Season averages (SEM) for the different localities for 1986-87 were: 84.4 (19.9) for Site 1, 55.7 (8.4) for Site 2, and 73.3 (9.0) for Site 3. Population peaks were as follows: Sites 1 and 3, 19 November with 373 and 180.4 bugs/clump, respectively; and Site 2, 19 December with 123.8 bugs/clump (Figure 6). Again, Site 1 had the highest levels of bugs but the difference was not as marked as the previous year. The populations in Sites 1 and 2 showed consistent decreases in bugs/clump as the sampling progressed; however, in Site 3, the population decreased after its peak in 19 November but
Figure 5. Abundance of overwintering chinch bugs/A. virginicus clump collected in two sites, 1985-86; (A) Site 1. (B) Site 2.
Figure 6. Abundance of overwintering chinch bugs/A. virginicus clump collected in three sites, 1986-87; (A) Site 1. (B) Site 2. (C) Site 3.
Mean No. of bugs/clump

Date

10/20
11/19
12/18
1/2
1/14
1/30
2/14
3/13
4/13
4/22
appeared to increase between 14 February and 2 April. After this date, the population started to decline again.

The first chinch bugs captured in flight traps during the spring of 1986 were on 17 March and peak emergence occurred on 3 April. From the spring emergence patterns observed for the three years, it can be assumed that the number of chinch bugs found in Andropogon clumps ca. 1 month before peak emergence represent adequately the survival of the overwintering population. Survival estimates of the population at the two sites for 1985-86 were obtained using the number of insects/clump collected on 5 March. Survival percentages for the season were 11.2 for Site 1 and 53.6 for Site 2. For the 1986-87 season, survival estimates were based on the number of bugs/clump collected on 13 March, which was the first day that a chinch bug was caught in our flight traps. Survival was ca. the same in Sites 1 and 2 and slightly higher in Site 3. Percentages were 13.5 for Site 1, 17.1 for Site 2, and 24.8 for Site 3. Population levels in Sites 1 and 2 did not differ as much as in 1985-86. In addition, survival percentages for 1986-87 were ca. at the same levels. If density dependent mortality factors are in operation, it is possible that the population density of the sites may have influenced the survival of the population in Site 2 during 1985-86.

In general, the overwintering populations peaked sometime in the late fall to early winter, November to December, and started showing declining population levels in January. An attempt was made to correlate the decreases in numbers of chinch bugs/clump with rainfall and temperature patterns as possible mortality factors but no strong relationships could be found. Shelford & Flint (1943) suggested that
below normal precipitation in August through October often yielded large overwintering populations following a small one in successive years in Illinois. Their findings may be true on a wide area basis but not necessarily on small localized populations like the ones considered in this study. Other possible mortality agents may include diseases such as *Beauveria* spp. and predators.

The factors that influence chinch bug abundance at the different overwintering sites could not be determined. Factors that may influence overwintering include proximity to small grain production fields, biomass of the overwintering host plant as suggested by Lamp & Holtzer (1980), burning, mowing and pesticide use history in the area, and particular characteristics of the microhabitat.

The data indicate that the life history of the chinch bug in Louisiana and other parts of the southeastern United States, differs in various regards from the previously reported life history in the mid-western states. Chinch bugs infesting both corn and wheat are overwintered insects emerging in March and April. Movement into both crops is mainly by flight. Infestations in the Mid-west were attributed to overwintering chinch bugs flying into wheat and first generation chinch bugs moving on the ground into corn. In the South, peak spring emergence appears to be triggered by temperatures of 26 to 27 °C or above and it is likely to be the same way in the Corn Belt. Fall migrations in the South take place in September through November with most of the movement occurring in October; this does not differ from previous reports from the mid-western states. No winter-long data could be found in the literature relating overwintering populations in the Mid-west; however, peak
overwintering populations in the South occurred in November and December and started decreasing in January. Only Site 2 during the 1985-86 sampling had a survival percentage over 50%. This was the site with the smallest population levels for both years. Survival percentages were between the 10% and 25% level at the other sites.

Chinch bugs pose a threat to seedling corn in Louisiana as a result of their emergence from overwintering sites soon after corn has been planted and while it is still at an early vegetative stage of development (Negron & Riley 1985). There have been no reports of chinch bugs damaging wheat in Louisiana because, at this time of the year wheat is nearing maturity and is past the susceptible stage.

Additional studies to determine specific mortality factors that effect overwintering chinch bugs should be undertaken. This type of information will help to more accurately characterize the overwintering habits of the chinch bug and to a better understanding of the ecology of this insect.
References Cited


CHAPTER II

Influence of Temperature
on the Immature Stages of the
Chinch Bug

(Heteroptera: Lygaeidae).
Abstract

Nymphal development of *Blissus leucopterus leucopterus* (Say) was significantly faster at 28°C than at 22°C. Males developed significantly faster than females at 22°C but not at 28°C. Egg incubation period was significantly shorter at 28°C than at 22°C. The percentage of eggs hatching was not significantly affected by temperature. Results are compared with developmental data available for other species of *Blissus*.
Introduction

MANY ASPECTS of the biology of the chinch bug, *Blissus leucopterus leucopterus* (Say), have been studied. Luginbill (1922) conducted studies on oviposition, egg incubation periods, and development. Janes (1935) showed that egg production was higher at 29.5°C than at 24.5°C or 35.5°C and that overwintered females produced more eggs/female than females of later generations. Snelling (1937) reported differential development on various sorghum, *Sorghum bicolor* (L.) Moench, varieties. Smith et al. (1981) studied developmental rates, oviposition, and longevity in different host plants. More recently developmental rate and fecundity were among the parameters used by Mize and Wilde (1986, 1986a) in host plant resistance studies in sorghum. Wilde et al. (1986) used reproduction as criteria for evaluation of resistance in selected small grains genetic sources.

Biological information has also been obtained for other members of the "leucopterus complex". Mailloux and Streu (1981) conducted studies on the population biology of *Blissus leucopterus hirtus* Montandon, the hairy chinch bug. Baker et al. (1981) also working with *B. l. hirtus* conducted rearing studies and determined developmental times and preoviposition periods. Kerr (1966) studied various aspects of the biology of *Blissus insularis* Barber, the Lawn chinch bug, in Florida. Komblas (1962) studied the biology and control of *Blissus leucopterus insularis* (= *B. insularis*) in Louisiana.

Comparative data on the development and egg hatching of *Blissus leucopterus leucopterus* will be of value in achieving a better
understanding of this insect and of the biological relationships among members of the "leucopterus complex". The objectives of this study were to compare chinch bug development at two different temperatures by measuring the duration of each stadium and to study the effect of temperature on egg survival and development.

Materials and Methods

Overwintering chinch bugs were collected in the spring of 1986 from *Andropogon virginicus* L. prior to spring emergence. Fifteen pairs were placed in petri dishes and placed in an environmental chamber at 28°C and a 14:10 (L:D) photoperiod. Food for all adults and developing nymphs consisted of sections of greenhouse grown corn, *Zea mays* L., plants ca. 10-14 days old and changed daily. Insects were monitored daily and eggs deposited were transferred to separate petri dishes and placed in a clear plastic box with moistened paper towel on the bottom to prevent desiccation. Egg hatching was monitored daily and data recorded. First instar nymphs were placed in petri dishes to monitor the duration of each stadium and total nymphal developmental time. To prevent bias due to genetic influences, an equal number of first instars from each set of parents was used. Developmental time and egg hatching was monitored at two temperature regimes: 22°C and 28°C both at a 14:10 (L:D) photoperiod. Leonard's (1968) description of *Blissus* immature stages was used as a guide for identification of the different instars. Statistical comparisons of developmental times at the different temperatures were made with t-tests using data from 43 insects at 28°C and 59 insects at 22°C (SAS Institute 1985). Hatching percentages were also compared by performing a t-test on arcsine transformed data from 10
sets of parents at 28°C and 7 at 22°C (SAS Institute 1985).

**Results and Discussion**

Chinch bugs took almost twice as much time to develop at 22°C as compared with 28°C (Table 1). This agrees with studies conducted by Kerr (1966) with *Blissus insularis* where a longer developmental time at a lower temperature was also reported. At both temperatures the longest stages were the first and fifth instars, respectively.

Males developed faster than females at both temperatures and the difference was significant ($t = 3.79$, df = 57, $P > 0.01$) at 22°C but not at 28°C (Table 2). No data could be found in the literature comparing total developmental times of males and females. Smith et al. (1981) reported total developmental times for *B. l. leucopterus*, on various host plants at 28°C and a 16:10 (L:D) photoperiod. They reported a faster developmental time on sorghum (28.4 days) than on corn (31.8 days). The total developmental time obtained in our study at 28°C, 30.4 days, compares well with their results. Developmental times and stadia duration was studied by Baker et al. (1981) with *Blissus leucopterus hirtus* Montandon on corn (although this species is commonly a pest of turfgrasses), with a 16-h photoperiod. Kerr (1966) did the same with *Blissus insularis* Barber on St. Augustinegrass, *Stenotaphrum secundatum* (Walker) Kuntze, at 28.3°C and 21.1°C; and Komblas (1962) also with *Blissus leucopterus insularis* (= *B. insularis*) in outdoor cages in St. Augustinegrass. Our data at 28°C, and that of Baker et al. (1981) are similar for all of the nymphal stages although the developmental time of each instar was slightly longer for *B. l. hirtus* when compared to *B. l. leucopterus*. Total developmental time was ca. 5 days more for *B. l.*
Table 1. Mean (SEM) duration (days) of immature stages of *B. leucopterus* at two temperature regimes and a 14:10 (L:D) photoperiod

<table>
<thead>
<tr>
<th></th>
<th>Egg (SEM)</th>
<th>1st (SEM)</th>
<th>2nd (SEM)</th>
<th>3rd (SEM)</th>
<th>4th (SEM)</th>
<th>5th (SEM)</th>
<th>Total (SEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22°C</td>
<td>21.1 (0.07)</td>
<td>16.2 (0.79)</td>
<td>7.2 (0.22)</td>
<td>8.1 (0.2)</td>
<td>9.8 (0.22)</td>
<td>13.7 (0.2)</td>
<td>55.1 (1.04)</td>
</tr>
<tr>
<td>28°C</td>
<td>13.1 (0.04)</td>
<td>10.0 (0.61)</td>
<td>5.1 (0.34)</td>
<td>4.4 (0.27)</td>
<td>4.3 (0.17)</td>
<td>6.6 (0.28)</td>
<td>30.4 (0.78)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>t-value</th>
<th>df</th>
<th>P-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>110.44</td>
<td>919</td>
<td>0.01**</td>
</tr>
<tr>
<td>5.85</td>
<td>100</td>
<td>0.01**</td>
</tr>
<tr>
<td>5.22</td>
<td>100</td>
<td>0.01**</td>
</tr>
<tr>
<td>11.19</td>
<td>100</td>
<td>0.01**</td>
</tr>
<tr>
<td>18.6</td>
<td>100</td>
<td>0.01**</td>
</tr>
<tr>
<td>21.16</td>
<td>100</td>
<td>0.01**</td>
</tr>
<tr>
<td>17.80</td>
<td>100</td>
<td>0.01**</td>
</tr>
</tbody>
</table>

*3/ 43 insects reared at 28°C and 59 at 22°C

*b/ 606 eggs hatched at 28°C and 313 at 22°C
Table 2. Mean (SEM) total developmental time (days) for B. _leucopterus_ males and females at two temperature regimes and a 14:10 (L:D) photoperiod

<table>
<thead>
<tr>
<th></th>
<th>22°C</th>
<th>28°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>males</td>
<td>52.03 (1.0)</td>
<td>29.23 (0.9)</td>
</tr>
<tr>
<td>females</td>
<td>59.20 (1.7)</td>
<td>32.10 (1.4)</td>
</tr>
<tr>
<td>t-value</td>
<td>3.79</td>
<td>1.86</td>
</tr>
<tr>
<td>df</td>
<td>57</td>
<td>41</td>
</tr>
<tr>
<td>P-level</td>
<td>0.01**</td>
<td>0.07NS</td>
</tr>
</tbody>
</table>
hirtus. The data presented by Kerr (1966) with B. insularis indicated shorter developmental times for the first three instars and similar times for the last two instars and the total developmental time was ca. 5 days shorter for B. insularis as compared with B. l. leucopterus. Komblas (1962) presented developmental times for B. insularis of 43 to 49 days. His studies were conducted in petri dishes placed outdoors and were probably exposed to a wide variety of environmental fluctuations making the data hard to compare with other studies. Luginbill (1922) studied the duration of each instar of B. leucopterus. However, this research was conducted in South Carolina, thus it probably was with B. l. leucopterus since according to distribution maps by Leonard (1966) B. l. hirtus does not occur in South Carolina. Luginbill's (1922) data were also similar to our 28°C data, except that the duration of the fourth and fifth instars was about three times longer and total developmental time was 60.4 days. Luginbill (1922) stated that the developmental time in his study was probably extended because of unnatural conditions. Developmental time of nymphs at 28°C ranks from longest to shortest as follows: B. l. hirtus > B. l. leucopterus > B. insularis.

Kerr (1966) also studied development at 21.1°C and found that the lower temperature increased developmental time in B. insularis from 25.5 to 68.9 days. Temperature appears to have a stronger influence on the development of B. insularis than on B. l. leucopterus since the developmental time of the former was increased by a greater factor than that of B. l. leucopterus (Table 1).

Of the total of 1,202 eggs monitored for hatching, in the study, 76.5%, or 919, hatched. At 28°C, 78.8% (606 out of 769) of the eggs
hatched and the incubation period ranged from 10 to 15 days (Figure 1). Of these 94% (570 out of 606) hatched between 12 and 14 days and the mean incubation period was 13.1 ± 0.04 (SEM) (Table 1).

At 22°C, the percentage of egg hatch was slightly reduced to 72.3% (313 out of 433) but not significantly (t = 0.85; df = 15; P = 0.41) as compared with hatching at 28°C, and the incubation period was extended, ranging from 17 to 25 days (Figure 2). The mean incubation period was 21.0 ± 0.07 (SEM) days and 91.7% (287 out of 313) of the eggs hatched between 20 and 23 days (Table 1).

Luginbill (1922) made the first experimental attempt to determine the incubation period of B. leucopterus (= B. 1. leucopterus) eggs and reported that the incubation period ranged from 9 to 31 days with an average of 21.9 days. This probably represented eggs exposed to varying conditions during the growing season. Komblas (1961) also studied incubation periods for B. insularis and reported 28.7, 15.2, and 14.2 days for incubation for the 1st, 2nd, and 3rd generations, respectively; however, as previously mentioned environmental fluctuations probably influenced his results making the data difficult to compare. Mailloux and Streu (1981) showed incubation periods for eggs of B. 1. hirtus of 18.5 days at 21°C, 14 at 22°C, 12 at 24°C, 8 at 30°C, and 7 at 35°C, and suggested 14.6°C as a threshold temperature for egg development. Kerr (1966) reported incubation periods for B. insularis eggs of 8.8 days at 28.3°C and 24.6 days at 21.1°C. Kerr (1966) also found overall hatching percentages of 81.8%. Smith et al. (1981) showed hatch percentages for B. 1. leucopterus in excess of 94% in various host plants.

At the 21°C to 22°C range the ranking in egg incubation periods
Figure 1. Total number of B. l. leucopterus eggs hatching and their incubation period (days) at 28°C and a 14:10 (L:D) photoperiod.
No. Hatching Eggs

\[ X = 13.1 \pm 0.04 \text{ (SEM)} \]

\[ N = 606 \]
Figure 2. Total number of B. l. *leucopterus* eggs hatching and their incubation period (days) at 22°C and a 14:10 (L:D) photoperiod.
No. Hatching Eggs

$X = 21.0 \pm 0.07$ (SEM)

$N = 313$

Incubation Period (Days)
is B. insularis > B. 1. leucopterus > B. 1. hirtus which is the reverse of the trend observed for nymphal developmental times. B. 1. leucopterus had a longer incubation period than the other two species at the 28°C to 30°C range. It is not possible to compare Lunginbill's (1922) or Komblas' (1962) data at this point since they seem to have included a wide range of environmental conditions.

Considering egg survival, Smith et al. (1981) showed higher survival for B. 1. leucopterus than the survival obtained in this study. Survival reported by Kerr (1966) for B. insularis are comparable to ours.

In this study, temperature had a significant influence in the nymphal developmental rate of B. 1. leucopterus. However it is of interest to note that only a slight effect in the percent of eggs that hatched was observed.

Although the authors realize that it is hard to compare biological information obtained by different researchers due to differences in methodology, the trends observed, pose interesting questions regarding the biological relationships of these members of the "leucopterus complex". It would be of interest to conduct biological studies under the same conditions and with consistent methodology with each species to determine if there are real differences in developmental parameters among them.
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CHAPTER III

Effect of Chinch Bug (Heteroptera: Lygaeidae)

Feeding in Seedling Corn
ABSTRACT

Corn seedlings were infested for 7 days in greenhouse experiments with 0, 2, 5, 10, 15, and 20 field-collected adult *Blissus leucopterus leucopterus* (Say) at three different stages of plant development. A highly significant interaction between plant developmental stage and insect infestation rate was obtained. Plants infested at the V1, V2, and V2.5 stage of development exhibited significant reductions in plant height at infestation levels of 10, 15, and 20 insects per plant, respectively.
THE CHINCH BUG, *Blissus leucopterus leucopterus* (Say), is an occasional pest of corn and sorghum. In the past several years this insect has been reported to have damaged sorghum in eastern Kansas, and corn and sorghum in the southeastern portion of Nebraska (Mize et al. 1980, Peters 1983). Recently outbreaks have resulted in the need for control in corn and sorghum in north Louisiana (J.L. Baldwin, personal communication).

Chinch bugs cause damage by sucking plant juices from the base of the stem and from the roots of plants. Their feeding can result in wilting, stunting, and even death of the plant, depending upon the number of insects and the age of the plant. Wilde and Morgan (1978) reported that 30 chinch bugs per plant killed sorghum seedlings 75-125 mm in height in 6-7 days. Fewer chinch bugs caused either death or severe stunting, depending on plant size. Similar information is needed to relate the number of chinch bugs to mortality and damage of seedling corn plants, no detailed data of this kind is presently available on which to base accurate management practices for this insect in corn. In our study, we determined the damage caused by populations of chinch bugs in corn seedlings at three stages of plant development.

**Materials and Methods**

The study was conducted during the summer of 1984 in a greenhouse at Baton Rouge, La. The temperature during the experiment was 32 ± 2°C with a 60 ± 10% RH and a 14:10 (L:D) photoperiod. 'Pioneer Brand 3369-A' hybrid seed corn seedlings (one seedling in a
3.78-liter plastic pot) were used for the experiment.

Three stages of plant development were used for experimentation. These were as follows: third leaf 10.2 cm in extended leaf height; fourth leaf 26.4 cm in height; and fifth leaf 28.8 cm in height. The first two stages correspond with the respective V1 and V2 stages of corn plant development according to Ritchie and Hanway (1982). The third stage was an intermediate between V2 and V3, which will be referred to as V2.5. Seedlings of each stage were infested with 0, 2, 5, 10, 15, and 20 field-collected adult chinch bugs per plant. These numbers represent the normal infestation levels found in north Louisiana cornfields in the early spring. The insects were confined on the seedlings with nylon screen cages for 7 days. Based on our field observations this approximates the time needed for a population to build up to damaging levels. On the day of infestation, the seedlings were watered at 8:00 a.m., and infested at ca. 3:00 p.m.; they were not watered again until after the insects were removed. Chinch bug damage was assessed by measuring plant height which was recorded immediately after insect removal, and again at 1 and 2 weeks after removal. Recording plant height at these different times would indicate whether the plants compensated for chinch bug damage over time. Plant height was determined by measuring the most recently emerged leaf in the whorl. If present, observations of wilting were also taken. Before infestation, the plants were separated into six experimental groups; each group had the same mean height. The experiment was arranged as a completely randomized design with 10 observations per treatment. The data were subjected to analysis of variance and means were separated using Duncan's (1951) multiple
range test.

Results and Discussion

A highly significant interaction between plant developmental stage and infestation rate was obtained, suggesting that chinch bug damage to corn seedlings is strongly influenced by the stage of growth of the plant (P < 0.01). At the end of the infestation period for the V1 plants, two insects per plant were enough to cause significant reductions in plant height and to cause slight wilting of the plants (P < 0.05) (Table 1). Infestation levels of 5-20 insects per plant further reduced plant height significantly (P < 0.05). One week after the insects were removed, infestations of 2, 5, and 10 insects per plant showed no significant reductions in plant height (P < 0.05). These infestation levels did, however, cause moderate degrees of wilting, especially at the rate of 10 insects per plant. After 2 weeks, plants infested with 2 and 5 insects per plant did not exhibit reduced plant height when compared to the control, but plants infested with 10, 15, and 20 insects per plant still showed significantly reduced height when compared to the control (P < 0.05).

At the time of insect removal from the V2 plants, infestation rates of 2, 5, and 10 insects per plant produced only slight wilting and a decreasing trend in plant height. However, only plants infested with 15 and 20 insects per plant suffered moderate wilting and had significantly reduced plant height when compared to the control (P < 0.05). One week after insect removal, plants infested with 10, 15, and 20 insects per plant had reduced height when compared to those infested with 0, 2, and 5 insects per plant, but differences were not significant (P > 0.05). Two weeks after
Table 1. Mean heights (cm) of corn seedlings, infested at the V1, V2, and V2.5 stages of plant development with B. l. leucopterum at date of insect removal, 1 week, and 2 weeks after insect removal

<table>
<thead>
<tr>
<th>Time of measurement</th>
<th>No. of insects per plant</th>
<th>Leaf measured</th>
<th>Mean(^b)</th>
<th>Leaf measured</th>
<th>Mean(^b)</th>
<th>Leaf measured</th>
<th>Mean(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of insect removal</td>
<td>0 4th</td>
<td>34.8a</td>
<td>5th</td>
<td>20.3a</td>
<td>6th</td>
<td>41.3ab</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 4th</td>
<td>26.5b</td>
<td>5th</td>
<td>20.2a</td>
<td>6th</td>
<td>36.8ab</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 4th</td>
<td>18.5c</td>
<td>5th</td>
<td>19.8a</td>
<td>6th</td>
<td>43.4a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 4th</td>
<td>15.9c</td>
<td>5th</td>
<td>17.0ab</td>
<td>6th</td>
<td>36.3b</td>
<td></td>
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<tr>
<td></td>
<td>15 4th</td>
<td>14.6c</td>
<td>5th</td>
<td>13.9bc</td>
<td>6th</td>
<td>38.5ab</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20 4th</td>
<td>15.1c</td>
<td>5th</td>
<td>12.7c</td>
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Table 1. Continued.

<table>
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<th>Time of measurement</th>
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<th>V1</th>
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<th>V2.5</th>
</tr>
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<tbody>
<tr>
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<td>Leaf</td>
<td>Mean&lt;sup&gt;b&lt;/sup&gt;</td>
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</tr>
<tr>
<td>1 wk.</td>
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<td>5th</td>
<td>29.6ab</td>
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</tr>
<tr>
<td>after insect removal</td>
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<td>28.3ab</td>
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</tr>
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<td>10</td>
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Table 1. Continued.

<table>
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<th>Leaf measured</th>
<th>Mean*3</th>
<th>ht. measured</th>
<th>Leaf Mean*3</th>
<th>ht. measured</th>
<th>Leaf Mean*3</th>
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<th>Leaf Mean*3</th>
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<tr>
<td>2 wks.</td>
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<td>8th</td>
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<td></td>
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<tr>
<td>After Insect</td>
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<td>8th</td>
<td>97.3a</td>
<td>11th</td>
<td>73.3a</td>
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<td></td>
<td></td>
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<tr>
<td>Removal</td>
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<td>14.4ab</td>
<td>8th</td>
<td>89.2ab</td>
<td>11th</td>
<td>68.1a</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>10.4b</td>
<td>8th</td>
<td>80.3b</td>
<td>11th</td>
<td>68.3a</td>
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<td></td>
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<td></td>
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<td>86.8ab</td>
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<td>54.0b</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Stage of plant development as determined by the method of Ritchie and Hanway (1982).

Means followed by the same letter are not significantly different at the P = 0.05 level (Duncan's [1951] multiple range test).
infestation, the 15 insects per plant treatment had significantly reduced plant height when compared with the control ($P < 0.01$).

When the infestation period ended for the V2.5 plants, only the treatment of 20 insects per plant caused significant reductions in plant height. Wilting was also observed in these plants ($P < 0.05$). The same trend was also observed at the 1 and 2 weeks after treatment measurements.

These results suggest that the stage of plant development in which corn seedlings are attacked by chinch bugs has a major influence on the expression of plant damage. Older corn seedlings are better able to withstand higher populations of chinch bugs than younger plants. This is illustrated by the higher infestation rates needed to cause significant reductions in plant height as the age of the plants progressed until two weeks after infestation ($P < 0.05$). These rates were 10 insects per plant for V1 plants, 15 insects per plant for V2 plants and 20, insects per plant for V2.5 plants, respectively. Moreover, plants infested with these rates at their respective stage were not able to compensate for chinch bug damage during the 2-week period after infestation ceased.

Ahmad et al. (1984), working with sorghum, conducted an experiment similar to the one presented here. They reported that apparent visual recovery of the plants after removal of the insects may not ensure normal grain yields. In our study, infested plants had not recovered fully 2 weeks after insect removal. It is possible that given more time recovery could have taken place. However, considering the findings of Ahmad et al. (1984), yield reductions in corn due to chinch bug feeding may occur after visible recovery of
the plants has taken place.
References Cited


CHAPTER IV

Longterm Effects of Chinch Bug
(Heteroptera: Lygaeidae)
Feeding in Corn
Abstract

Field studies were conducted during 1986 and 1987 to evaluate effects of *Blissus leucopterus leucopterus* (Say), feeding in field corn, *Zea mays* L. Corn plants were infested at two stages of plant development with adult chinch bugs. Additionally, plants damaged by natural infestations of chinch bugs were rated into no damage, slight, moderate, and heavy damage classes and followed to maturity. Results indicated that young plants were most susceptible to damage and reduced performance of plants was evident in plants with slight or greater levels of damage.
Introduction

IN RECENT YEARS the chinch bug, *Blissus leucopterus leucopterus* (Say), has become a serious concern for corn, *Zea mays* L., growers in northeastern Louisiana. Chinch bugs cause damage to seedlings by feeding on plant juices at the base of the plant. Young seedlings are most susceptible to chinch bug damage and as the age and size of the plants increase the damage threshold increases (Negron & Riley 1985). Wilde & Morgan (1978) reported death of sorghum, *Sorghum bicolor* (L.) Moench, seedlings 75-125 mm in height after 6-7 days exposure to 30 chinch bugs, and lower densities caused severe damage. Ahmad et al. (1984) suggested that apparent visual recovery of sorghum plants exposed to chinch bug attack may not ensure normal yields.

Additional data are needed to relate chinch bug infestations to season-long plant performance in order to improve management guidelines for chinch bugs in Louisiana and other parts of the southern United States. In this study corn plant growth and development were evaluated after exposure to chinch bug populations. Moreover, plants damaged by chinch bugs during the seedling stage were followed to maturity in an effort to ascertain the fate of plants damaged by chinch bug feeding early in their development.

Materials and Methods

Field cage studies. The longterm effects of chinch bug feeding in corn were evaluated in field experiments during 1986 and 1987. Pioneer Brand 3055 field corn was planted at the St. Gabriel Research Station, Iberville Parish, La., on 15 April 1986 and 18
April and 19 May 1987.

Each year six chinch bug infestation levels and two corn plant developmental stages were evaluated. Infestation levels were 0, 2, 5, 10, 15 and 20 field-collected adults per plant. The levels used represent normal infestation levels of chinch bugs in field corn in Louisiana early in the spring. Infestations were made when plants were at the V2 and V5 plant developmental stages (Ritchie and Hanway 1982). These represent the stages of plant development attacked by chinch bugs in Louisiana.

Four corn plants were enclosed in a 1.2 by 0.3 by 0.6 m PVC cage and covered with 0.5 mm mesh fabric. The insects were released inside the cage and the edges covered with soil. The study was conducted in a completely randomized design with four replications. Each replication consisted of six cages, one for each infestation level. During 1986, the study was conducted as a factorial experiment infesting both stages of plant development in the same field. In 1987, two different fields were used, one for each of the plant developmental stages.

Infestation periods lasted for 9 days, after which the cages were removed and plants treated with a granular insecticide at the base to kill the chinch bugs and at the whorls to prevent attack by other insects. Measurements of extended leaf heights were taken the day after termination of the infestation period and ca. one and two weeks after termination for V2 plants and the day after termination and ca. one week after for V5 plants or as close to this as weather permitted. Plants were then allowed to mature and the ears hand harvested and dried to 13% moisture content. In the laboratory data
were collected on ear weight and ear length. All variables measured were subjected to analysis of variance (SAS Institute 1985) and means separated using Duncan's (1955) multiple range test.

Naturally infested plants. Pioneer Brand 3165 field corn was planted on 7 April 1987 at the Macon Ridge Branch of the Northeast Research Station, Franklin Parish, La. The site was an experimental test plot of granular soil insecticides for chinch bug control. Included in the test were the most widely used soil insecticides in corn in Louisiana. These along with their mode of application were carbofuran 15G in furrow, chlorpyrifos 15G in furrow and in a band, and turberfos 10G in furrow and in a band. All compounds were applied at the 1.1 kg (AI)/ha rate. In addition untreated control plots were present. Pressure by the chinch bug population was sufficient to cause varying levels of plant damage. When most of the plants were at the V6 stage of plant development 40 plants showing symptoms of chinch bug damage were selected in each of the insecticide plots and in the untreated plot. Selected plants were rated and 10 plants placed in each of the following damage categories: 1) no damage, plants showing no evidence of chinch bug feeding and with average height; 2) slight damage, plants showing slight amounts of chinch bug feeding, reddish discoloration at base of plant, straight stem but of reduced height with distances between leaf collars reduced when compared to a no damage plant; 3) moderate damage, basal part of plant starting to show evidence of damage, reduced height, and stem curving at base of plant; and 4) heavy damage, severely stunted plants, dead leaves may be present, severe damage at base of plant, and leaves entangled with one another. The
experiment was a randomized complete block design using insecticides as blocks and individual plants as the sampling unit. Since it was not possible to find 10 plants showing heavy damage in all of the plots, there was a smaller sample size for the heavy damage class.

Plants were marked with garden stakes and allowed to mature. At maturity, the ears were hand harvested and dried to 13% moisture content. In the laboratory data were collected on ear weight and ear length. The variables were subjected to analysis of variance and means separated with Tukey's honestly significant difference test (SAS Institute 1985).

Results

Field cage studies. Results of the infestation level and plant developmental stage main effects for the 1986 part of the study are presented in Table 1. Although significant differences in ear weight were not detected for the infestation level effect, there was a trend of decreasing ear weight as the number of insects increased and a considerable difference between the 20 insect/plant level and the control. For the plant stage main effect, plants infested at the V2 stage of development had significantly reduced ear weight when compared to the V5 infested plants ($F = 8.9; df = 1, 36; P < 0.005$). Ear length however, was unaffected for both the infestation level and plant developmental stage main effects.

Presented in Tables 2 and 3 are the results for the effect of the infestation levels on all the variables measured for the V2 and V5 infested plants, respectively, during 1986. A trend of decreasing ear weight was noted with increasing number of insects in the V2
<table>
<thead>
<tr>
<th>No. of Insects</th>
<th>Ear Weight (g)</th>
<th>Ear Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>204.6a</td>
<td>16.3a</td>
</tr>
<tr>
<td>2</td>
<td>199.5a</td>
<td>16.6a</td>
</tr>
<tr>
<td>5</td>
<td>187.0a</td>
<td>15.4a</td>
</tr>
<tr>
<td>10</td>
<td>185.2a</td>
<td>16.1a</td>
</tr>
<tr>
<td>15</td>
<td>190.2a</td>
<td>16.1a</td>
</tr>
<tr>
<td>20</td>
<td>180.7a</td>
<td>15.4a</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Plant Stage</th>
<th>Ear Weight (g)</th>
<th>Ear Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V2</td>
<td>176.8b</td>
<td>16.0a</td>
</tr>
<tr>
<td>V5</td>
<td>205.6a</td>
<td>15.9a</td>
</tr>
</tbody>
</table>

*Means within columns followed by the same letter are not significantly different (*P* = 0.05; Duncan's [1955] multiple range test).*

*Means within columns followed by the same letter are not significantly different (*P* = 0.05; ANOVA).*
Table 2. Corn plant height at 1, 8, and 15 days post-infestation, ear weight (g), and ear length (cm) of plants infested at the V2 stage of development with *B. leucopterus leucopterus*, 1986

<table>
<thead>
<tr>
<th>No. of Insects</th>
<th>1 day</th>
<th>8 days</th>
<th>15 days</th>
<th>Ear Weight (g)</th>
<th>Ear Length (cm)</th>
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</thead>
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<td>191.2a</td>
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<td>74.3a</td>
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<td>199.4a</td>
<td>17.1a</td>
</tr>
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<td>5</td>
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<td>70.3a</td>
<td>118.2a</td>
<td>166.2a</td>
<td>15.0a</td>
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<tr>
<td>10</td>
<td>48.7a</td>
<td>70.1a</td>
<td>114.7a</td>
<td>171.7a</td>
<td>16.3a</td>
</tr>
<tr>
<td>15</td>
<td>45.5a</td>
<td>72.5a</td>
<td>110.9a</td>
<td>168.2a</td>
<td>15.8a</td>
</tr>
<tr>
<td>20</td>
<td>46.8a</td>
<td>70.4a</td>
<td>109.0a</td>
<td>164.5</td>
<td>15.3a</td>
</tr>
</tbody>
</table>

Means within columns followed by the same letter are not significantly different (*P* = 0.05; Duncan's [1955] multiple range test).
Table 3. Corn plant height at 1 and 7 days post-infestation, ear weight (g), and ear length (cm) of plants infested at the V5 stage of development with *B. leucopterus leucopterus*, 1986

<table>
<thead>
<tr>
<th>No. of Insects</th>
<th>1 day</th>
<th>7 days</th>
<th>Ear Weight (g)</th>
<th>Ear Length (cm)</th>
</tr>
</thead>
<tbody>
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<td>218.1a</td>
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</tr>
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<td>108.3a</td>
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<tr>
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<td>116.6a</td>
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<tr>
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<td>106.9a</td>
<td>196.9a</td>
<td>15.5a</td>
</tr>
</tbody>
</table>

Means within columns followed by the same letter are not significantly different (*P* = 0.05; Duncan's [1955] multiple range test).
infested plants. However, no significant differences were detected due to the infestation levels for any of the variables measured in any of the plant stages evaluated.

No significant differences were found for any of the variables measured due to the infestation levels evaluated in any of the plant stages tested in 1987 (Tables 4 and 5). The reduced ear weights observed for the V5 infested plants of 1987 may have been the result of delayed planting since this plot was planted ca. one month after the first field.

Naturally infested plants. No significant differences were detected due to the effects of the different test plots used (insecticides versus untreated plots). Reductions in ear weight and ear length were observed with each increment in the damage category and the differences were significant for both ear weight ($F = 84.2; df = 3, 171; P < 0.0001$) and ear length ($F = 73.2; df = 3, 171; P < 0.0001$) for the moderate and heavy damage classes (Table 6).

Discussion

Although the infestation level main effect results indicated a decreasing trend in ear weight (Table 1), the infestation levels used in this study did not have a severe impact on the performance of the corn plants as was indicated by the lack of significant differences in the variables measured attributable to the infestation levels in each of the plant stages infested (Tables 2, 3, 4, and 5); however, the results of the plant stage main effect (Table 1) indicated increased susceptibility to chinch bug damage at the younger stage of plant development. This is important factor because in Louisiana the chinch bugs coming emerge from overwintering sites and attack
Table 4. Corn plant height at 1, 9, and 17 days post-infestation, ear weight (g), and ear length (cm) of plants infested at the V2 stage of development with *B. leucopterus leucopterus*, St. Gabriel, 1987

<table>
<thead>
<tr>
<th>No. of Insects</th>
<th>1 day</th>
<th>9 days</th>
<th>17 days</th>
<th>Ear Weight (g)</th>
<th>Ear Length (cm)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>46.8a</td>
<td>74.3a</td>
<td>118.9a</td>
<td>188.5a</td>
<td>16.9a</td>
</tr>
<tr>
<td>2</td>
<td>47.4a</td>
<td>73.6a</td>
<td>120.4a</td>
<td>185.9a</td>
<td>15.8a</td>
</tr>
<tr>
<td>5</td>
<td>43.9a</td>
<td>69.3a</td>
<td>120.7a</td>
<td>188.6a</td>
<td>15.8a</td>
</tr>
<tr>
<td>10</td>
<td>42.5a</td>
<td>68.0a</td>
<td>116.8a</td>
<td>182.8a</td>
<td>15.4a</td>
</tr>
<tr>
<td>15</td>
<td>40.1a</td>
<td>65.1a</td>
<td>116.5a</td>
<td>189.7a</td>
<td>16.1a</td>
</tr>
<tr>
<td>20</td>
<td>43.3a</td>
<td>69.8a</td>
<td>119.6a</td>
<td>185.3a</td>
<td>16.3a</td>
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</table>

Means within columns followed by the same letter are not significantly different (*P* = 0.05; Duncan's [1955] multiple range test).
Table 5. Corn plant height at 5 and 8 days post-infestation, ear weight (g), and ear length (cm) of plants infested at the V5 stage of development with *B. leucopterus leucopterus*, St. Gabriel, 1987

<table>
<thead>
<tr>
<th>No. of Insects</th>
<th>5 day</th>
<th>8 days</th>
<th>Ear Weight (g)</th>
<th>Ear Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>90.7a</td>
<td>106.4a</td>
<td>134.7a</td>
<td>16.8a</td>
</tr>
<tr>
<td>2</td>
<td>91.8a</td>
<td>107.5a</td>
<td>134.6a</td>
<td>17.6a</td>
</tr>
<tr>
<td>5</td>
<td>91.9a</td>
<td>113.0a</td>
<td>141.8a</td>
<td>16.9a</td>
</tr>
<tr>
<td>10</td>
<td>93.4a</td>
<td>117.8a</td>
<td>133.7a</td>
<td>16.8a</td>
</tr>
<tr>
<td>15</td>
<td>85.1a</td>
<td>100.6a</td>
<td>140.5a</td>
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</tr>
<tr>
<td>20</td>
<td>87.5a</td>
<td>103.1a</td>
<td>132.4a</td>
<td>16.3a</td>
</tr>
</tbody>
</table>

Means within columns followed by the same letter are not significantly different (*P* = 0.05; Duncan's [1955] multiple range test).
Table 6. Ear weight (g) and ear length (cm) for plants damaged by *B. leucopterus leucopterus* and rated in four different damage classes, 1987

<table>
<thead>
<tr>
<th>Damage Class</th>
<th>N</th>
<th>Ear Weight (g)</th>
<th>Ear Length (cm)</th>
</tr>
</thead>
<tbody>
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<td>No Damage</td>
<td>60</td>
<td>272.1a</td>
<td>18.3a</td>
</tr>
<tr>
<td>Slight</td>
<td>58</td>
<td>242.9a</td>
<td>17.2a</td>
</tr>
<tr>
<td>Moderate</td>
<td>52</td>
<td>122.6b</td>
<td>11.7b</td>
</tr>
<tr>
<td>Heavy</td>
<td>24</td>
<td>21.0c</td>
<td>2.9c</td>
</tr>
</tbody>
</table>

Means within columns followed by the same letter are not significantly different (\( P = 0.05; \) Tukey's Honestly Significant Difference Test).
seedling corn in the spring (Negron 1988). In areas of high chinch bug incidence, planting corn as early as possible should prevent economic damage by having vigorously growing plants when chinch bugs emerge from overwintering.

The lack of significant differences due to the infestation levels may have been influenced by environmental factors. Chinch bugs are usually more injurious to plants under environmental stress, such as drought, in which case the chinch bugs become an added strain on the growing plant. It has been noted by the authors that under conditions of drought, soil insecticides applied at planting time for rootworm control that would normally afford some protection from chinch bugs fail to provide adequate protection. This is usually when rescue treatments become necessary. In the field cage study presented here the plants were not growing in stressed conditions. Although our experimental plots were planted without insecticides, the lack of environmental stress may have reduced the effects of chinch bug damage because the plants were more capable to withstand their attack.

Frequently, chinch bug infestations are undetected until plants begin to show damage. In this study, the duration of the infestation period was only 9 days. It would have been desirable to sustain a longer infestation period in order to simulate better field conditions and to understand better the effects of a prolonged infestation of few chinch bugs.

In the naturally infested plants experiment, plants showing slight amounts of damage in the early stages of development appeared to recuperate from damage. However, the results indicated that
slight damage by chinch bugs decreased ear weight and ear length (Table 6). The moderate and heavy damage categories produced significant decreases in both ear weight and ear length. Although the reductions at the slight level were not significant in this study they would probably be very meaningful on a per hectare basis. These data suggest that plants showing damage at the early stages of plant development may not recuperate and perform normally. Our data agrees with studies conducted by Ahmad et al. (1984) in sorghum and by Negron & Riley (1985) in corn.

From the field cage study, it was not possible to determine the number of insects needed to reduce plant performance. It can be concluded that plants in the earlier stages of development are more susceptible to chinch bug damage and that as determined by the naturally infested plants only slight levels of visual damage to seedlings caused by chinch bug feeding may have an impact on yield.

The infestation levels that caused the levels of damage described in the naturally infested plants study are not known. Negron & Riley (1985) reported persistent reductions in plant height in plants infested with chinch bugs 2 weeks after insect pressure was removed from the plants with the following levels: 10 insects/plant for V1 plants, 15 insects/plant for V2 plants, and 20 insects/plant for V2.5 plants. Since the damage described in the study by Negron & Riley (1985) is similar to that caused by slight chinch bug damage in the study presented here, we propose that these levels be used as working thresholds for chinch bugs in corn until additional data can be obtained.
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CONCLUDING REMARKS

The seasonal biology study presented adds new information on the life history of the chinch bug. The time of spring emergences do not appear to differ greatly in the South when compared to the Corn Belt states; however, they appeared to be influenced and predictable by ambient temperatures and it is likely to be similar in the Corn Belt. The damaging populations in corn in the South are the result of overwintering populations invading seedling corn by flight in the spring. The sticky flight trap used in this study has potential to become an easy to use and reliable sampling technique for chinch bugs invading corn fields and additional research is encouraged. The overwintering sampling presented here indicated peak populations in November and December and a decrease in the overwintering population as the winter progressed. Survival of overwintering populations appear to be generally between 10% and 25%. Future research should be undertaken in an attempt to identify specific mortality factors that effect overwintering chinch bugs.

Injury level studies on seedling corn revealed that younger plants are more susceptible to damage than plants at more advanced stages of development. Although this was not a surprising finding it was of interest to see that slight levels of chinch bug feeding were enough to cause reductions in ear weight and length. The results obtained in the greenhouse study indicated persistent reductions in plant height, two weeks after insect pressure was removed from the plants. The study in which naturally infested plants were followed to maturity indicated that slight damage, including reductions in
height, was enough to reduce plant performance. Using this information a working threshold of 10 insects/plant at the V1 stage of plant development, 15 at the V2, and 20 at the V2.5 is proposed until additional information relating yield reductions can be obtained.

The studies on the influence of temperature on the immature stages of the chinch bug also contribute new information on the biology of this species and presents an alternate way of studying the biological relationships of the species within the genus. The rearing technique may be laborious to be of significant use in large-scale screening studies but probably useful for studies involving the detection of mechanisms of resistance. Egg hatching was found to be retarded by temperature but the percentage hatching was not affected. This information will be of value for researchers that work with chinch bug colonies.
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Approved: 

Date of Examination: April 20, 1988