

ABSTRACT

MURILLO, AMY CHRISTINE. A Study of the Sugarcane Beetle (Coleoptera: Scarabaeidae) in North Carolina Turfgrass. (Under the direction of Rick L. Brandenburg.)

The sugarcane beetle (Coleoptera: Scarabaeidae) (*Euetheola humilis*) (Burmeister) is an emerging pest insect of managed turfgrass in North Carolina. It has been known for over a century as an agricultural pest. In turfgrass, it is distinguished from traditional scarab pests by having a different life cycle and damaging life stage.

The purpose of this research was to study the biology and ecology of the sugarcane beetle in managed turfgrass. Black light trapping was used to monitor adult flight activity and dissections were performed to determine egg presence in females. The beetle's life cycle in North Carolina has been elucidated. Turfgrass choice and no-choice tests, with a warm and cool season turf species, were conducted to determine habitat preference of the adult beetles.

Black light traps were used to monitor emergence and presence of adult beetles in fall 2009, spring and fall 2010, and spring 2011. Light traps were placed in Wake and Lee Counties of North Carolina. Traps were checked weekly from August through November (2009), March through December (2010), or May (2011). Following capture, beetles were either frozen or were kept in the laboratory on a diet of apples and bermudagrass. Dissections were conducted on both sexes of the fall 2010 and spring 2011 populations to: a) confirm beetle sex; b) document when eggs are present in females; and, c) depict male and female internal genitalia. These data were used to elucidate the life cycle of the sugarcane beetle in North Carolina. Adults overwinter until April. Adults mate, and females lay eggs until June. Larvae of various instars are present from late May through July. The overwintering

population gradually dies, and the new generation begins to emerge as adults in August and September.

North Carolina is within a climate transition zone where cool and warm season turfgrasses are grown throughout the state. Historically, the sugarcane beetle has been noted in warm season grasses, but any association with cool season turfgrass species is unknown. Small arena choice and no-choice tests were used to evaluate adult beetle movement between tall fescue (cool season) and bermudagrass (warm season) cores. It was hypothesized that adults would be attracted to bermudagrass, but our study did not reveal a significant difference between bermudagrass and tall fescue.

A Study of the Sugarcane Beetle (Coleoptera: Scarabaeidae)
in North Carolina Turfgrass

by
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DEDICATION

To My Family—

Thanks for always listening

BIOGRAPHY

Amy Christine (Lockwood) Murillo was born on December 30, 1987 in New York, New York. The daughter of Gary and Lori Lockwood, she is the older sister of Julie and Jamie Lockwood. Amy attended elementary and middle school in Waukesha, Wisconsin before graduating 8th in her class from Roxbury High School in Succasunna, New Jersey in 2006.

Amy attended Purdue University in West Lafayette, Indiana where she graduated with a Bachelor's of Science in Entomology with distinction and honors in May 2009. While attending Purdue, Amy played trombone in the Purdue All-American Marching band and the Boiler Brass pep band, scarcely missing a football or basketball game. This is how she met her husband, Kelly Murillo. Amy was an officer in the Thomas Say Entomological Society and worked numerous jobs within the Entomology Department during her tenure at Purdue. Amy began work on her Master's of Science degree in July 2009 under the supervision of Dr. Rick L. Brandenburg.

Upon the completion of her Master's degree, Amy will be heading west to Riverside, CA with Kelly, Morty, and Sophie. At the University of California at Riverside, she will pursue a doctorate degree in veterinary entomology under the direction of Dr. Bradley Mullens.

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Introduction and Literature Review

North Carolina is ranked eighth in the United States in acreage devoted to turfgrass, with about 800,000 hectares (2 million acres) under management. Over \$800 million are spent annually to maintain turfgrass acreage in North Carolina (Brandenburg et al. 2004). As the demand for high quality turfgrass acreage grows, so does the need for effective pest management.

North Carolina falls within a climate transition zone with respect to turfgrass, thus both cool and warm season species are grown throughout the state (Beard 1973). Historically, the most significant pests on cool season turfgrasses in the United States are white grubs (Potter and Braman 1991). White grubs are the larval form of beetles within the family Scarabaeidae. In North Carolina, white grubs are significant insect pests on cool and warm season grasses alike (Brandenburg et al. 2004). All beetles exhibit complete metamorphosis with four life stages: egg, larvae, pupae, and adult. Generally, the larval and adult stages are found within different ecological niches, and/or use different food source to minimize intraspecific competition. Most white grubs have a one-year life cycle; most overwinter as larvae or pupae, and the adults mate and lay eggs in spring (Potter and Braman 1991, Vittum et al. 1999).

White grubs aggressively feed before overwintering/pupating in late summer or early fall, when warm season turfgrass is going into dormancy, often resulting in severe turfgrass damage. This heavy feeding results in large patches of dead turfgrass that can be lifted easily from the soil, since the root system is eaten by the grubs (Potter and Braman 1999, Vittum et

al. 1999). In addition to the damage caused directly by white grubs, birds and mammals seeking to prey upon the grubs can cause additional damage to turfgrass.

In North Carolina, there are six important white grub pests in turfgrass; the Japanese beetle, *Popillia japonica*; northern and southern masked chafers, *Cyclocephala borealis* and *C. lurida*; May and June beetles, *Phyllophaga* spp.; the green June beetle, *Cotinis nitida*; and the Oriental beetle, *Anomala orientalis* (Brandenburg and Villani 1995, Freeman 2010, Vittum et al. 1999).

The Japanese beetle has a one-year life cycle in North Carolina. The adults emerge in early to mid- June, and mate immediately (Potter and Held 2002). The adults feed upon over 300 plant species, but are not considered turfgrass pests (Potter and Held 2002). Females oviposit in the upper 7.5 cm of soil, and the eggs hatch within two weeks. The grubs begin feeding on the roots and root hairs of turfgrass (Vittum et al. 1999). The damage by Japanese beetle grubs is characterized by widespread wilting and thinning, with high numbers resulting in turfgrass death (Vittum et al. 1999). In October, the third stage grubs retreat into the depths of the soil (5-15cm) to overwinter. In March, the grubs return to the upper layers of soil to feed for another 4-6 weeks before pupating (Potter and Held 2002).

Northern and southern masked chafers also have a one-year life cycle. Adults emerge and are active from June through July. Females oviposit in the upper 5 cm of moist, organic soil (Vittum et al. 1999). The adult beetles do not feed (Krischik and Davidson 2004). The eggs require 2-3 weeks to hatch. From August through October, the newly hatched grubs feed on the roots of turfgrass at the thatch layer. The most severe turfgrass injury due to these insects is caused by this late summer/early fall feeding (Brandenburg and Villani 1995). In

October, the third-instars dig deeper into the soil where they overwinter until late March-early April. The grubs feed upon the roots until pupation in mid- to late May (Vittum et al. 1999).

Beetles of the genus *Phyllophaga* are commonly known as May or June beetles. There are over 200 species of *Phyllophaga* found in North America, with about 39 species occurring in North Carolina (Brandenburg and Villani 1995, Brimely 1938). The life cycle for *Phyllophaga* species ranges from 1 to 4 years. Adults feed on foliage of trees, shrubs, herbs, and some turfgrasses; however turfgrass damage by the adults is rarely serious (Brandenburg and Villani 1995, Krischik and Davidson 2004). The larvae can cause serious turfgrass damage by feeding on roots close to the soil surface. Evidence of grub damage includes reduced growth, lack of dark green color and competition with weeds, and ultimately death (Brandenburg and Villani 1995). The larval stages tunnel below the frost line to overwinter, and for many species adult spring emergence is rainfall and temperature dependent (Brandenburg and Villani 1995).

Green June beetles have an annual life cycle. Adults are active from June through late July and eggs are laid throughout this period. Adults feed upon ripening fruit, such as apples, pears, and peaches (Krischik and Davidson 2004, personal observation of author). The first and second stage larvae cause turfgrass damage by creating horizontal tunnels in the thatch layer. This damage causes root breakage, thatch reduction, and soil instability (Brandenburg and Villani, 1995). Third stage grubs create deep vertical tunnels, leaving earthworm-like castings on the soil surface. Grub damage causes wilting of turfgrass, and in dry conditions, may cause turfgrass death. The large grubs will remain active until November, and then

tunnel over 20 cm into the soil to avoid cold conditions while overwintering. The larvae feed again in spring until pupation in May and June (Brandenburg and Villani 1995).

The Oriental beetle has a one-year life cycle in North Carolina. Adult beetles are active from late July-August and feed on roses, phlox, and petunias (Krischik and Davidson 2004). Eggs laid during this period require 17-25 days to hatch. Grubs cause turfgrass damage by feeding on roots (within 2.54 cm of) the soil surface. Grubs are fully grown by September, and move deeper into the soil to overwinter. In May, larvae return to the uppermost layer of soil to feed again before pupating in June.

White grub pests can be difficult to control since the damaging larvae occur below ground and cannot be monitored easily (Potter and Braman 1991). For this reason, adult populations are monitored and used to gauge larval presence (Freeman 2010). Light traps and pheromone traps can be used to attract adult beetles, depending on species. Insecticide applications for white grubs should follow peak adult flight as determined by trapping (Brandenburg and Villani 1995, Freeman 2010). This timing will help ensure a toxic concentration of insecticides as the larvae hatch from their eggs, when the grubs are most susceptible. Japanese beetles can be used as an indicator species as their lifecycle coincides with other white grub pests, and very effective pheromone traps are available for them (Freeman 2010).

Biological control has been explored for white grubs. Biocontrol agents include parasitic insects, such as *Hyperecteina aldrichi* (Diptera: Tachinidae), a natural enemy of the Japanese beetle. Parasites and parasitoids may not be the most effective means of control as they are often species specific and may not be sufficiently prevalent in high enough numbers

to impact pest populations (Freeman 2010, Potter and Braman 1991). Entomopathogenic nematodes and bacterial agents, such as *Bacillus papillae*, have been explored for white grub control as well, but results are often variable and may not defray expenses (Brandenburg and Villani 1995, Potter and Braman 1991).

Freeman (2010) conducted a 3-year comprehensive study of white grub pests in North Carolina using black light traps and pheromone traps at sod farms and golf courses. While all six of the aforementioned beetles were captured, a new scarab species, the sugarcane beetle, *Euethola humilis* (Burmeister), was also trapped extensively. About 10 years ago the sugarcane beetle was noted in North Carolina turfgrass (Rick Brandenburg, personal observation) but Freeman (2010) was the first to document it in significant numbers in managed turfgrass.

Sugarcane Beetle History

The sugarcane beetle (also known as the rough-headed corn stalk-beetle) was named and described in 1856 by LeConte as *Euethola rugiceps*. It was first considered a pest in 1880 when it was observed damaging sugarcane in Louisiana. The sugarcane beetle was subsequently observed damaging corn in 1888 by L.O. Howard in North Carolina and Mississippi (Philips and Fox 1924). Since then it has been a sporadic pest of sugarcane, corn, and rice (Baerg 1942, Philips and Fox 1924) and more recently in sweet potatoes (Smith 2006) in the southern states. Sugarcane beetles have been documented damaging tobacco (Scott 1956), greenhouse roses (Lyle 1933), and strawberries (Baerg 1942). Beetles have been observed in pastures in Arkansas and Louisiana (Philips and Fox 1924). Philips and Fox (1924) report that the beetle's normal food consists of certain grasses, especially those

belonging to the genus *Paspalum* Baerg (1942) found evidence that the beetles can live on bermudagrass (*Cynodon dactylon*). However, there is no literature to date of the sugarcane beetle as a pest of managed turfgrass.

Life History & Description

The sugarcane beetle belongs to the family Scarabaeidae and has a one-year life cycle in sugarcane, corn, and sweet potatoes (Philips and Fox 1917, Smith 2006). Philips and Fox (1917) first described the beetle's life cycle. Eggs are white, oblong, and grow to approximately 2 mm in diameter (Philips and Fox 1924). Females lay single eggs arbitrarily in moist soil, primarily in June (Philips and Fox 1924). Each female may lay up to 100 eggs over the course of several weeks (Baerg 1942, Philips and Fox 1924). Eggs hatch in two weeks, followed by approximately two months for the grubs to mature to third-instars.

Larvae of the sugarcane beetle resemble other white C-shaped grubs and grow to about 32 mm in length (Philips and Fox 1924). The grubs have red head capsules with distinct, coarse, dense punctures above the clypeus, as well as a unique raster pattern (Philips and Fox 1924, Ritcher 1966). The pupal stage takes approximately two weeks to complete, and most adults emerge in mid-September. The pale brown pupae are approximately 15 mm long (Philips and Fox 1924). When the adult beetles first emerge, the exoskeleton is shiny black (Philips and Fox 1924). The adult beetles feed in the fall, overwinter, and emerge around April to feed again. In the spring, adults mate underground (Philips and Fox 1924). Holman (1968) found that adult emergence is highly dependent on temperature. The minimum air and soil temperatures have to be above 18° C on the night of emergence, with the average temperature for air and soil being at least 14° C for a week prior.

Adult beetles are between 13 and 16 mm long and have small punctures along the abdomen which form vertical stripes. The forelegs are modified for digging and have four tibial teeth per leg. Teneral adults are shiny and maybe reddish in color before turning black. As the adult ages it becomes dull black. The clypeus is crested with two “teeth.” The pronotum is wider than it is long with the head often retracted if the beetle is not crawling (Philips and Fox 1924).

Injury

Only the adult sugarcane beetle has been recognized as pestiferous (Baerg 1942, Philips and Fox 1924, Smith 2006). In sugarcane and corn, the adult beetles cause injury by chewing on the stalk (Baerg 1942, Philips and Fox 1917). The females hollow out the stalks of sugarcane and lay eggs within it (Titus 1905). In corn and sugarcane, the beetles are most active in spring (Philips and Fox 1924). Tobacco seedling and greenhouse rose stems were chewed on at or below the soil surface by adult beetles (Lyle 1933, Scott 1956). Damage to sweet potatoes occurs when the beetles chew ragged holes into the root and feed and burrow on the plant (Smith 2006). In sweet potatoes, the fall population of beetles is more active and destructive (Smith 2006). There is no evidence of larval damage, and most references cite decayed plant or vegetable matter as their nutrient source (Ingram and Bynum 1932, Philips and Fox 1924).

Control

Cultural and chemical control measures have been investigated for the sugarcane beetle in agricultural crops. In 1880, candles lit over a pan of kerosene were used as a means to monitor and kill large number of beetles (American Entomologist 1880). The recommended

control in sugarcane was to eliminate poor drainage and old crop waste, crop rotation, early planting, and/or pasturing with hogs to root out grubs (Philips and Fox 1924).

In corn, Baerg (1942) recommended picking adult beetles by hand, annual intense cultivation, late planting, over-seeding then “chopping” corn, fall plowing, and plant rotation.

Baerg (1942) also noted that birds, skunks, and other insects may prey on the adults and larvae. In 1986, Riley tested seven different granular soil insecticides for sugarcane beetle control in field corn. In 2006, Smith investigated six different insecticides for sugarcane beetles in sweet potatoes, and found that early planting dates were the best way to reduce sugarcane beetle damage.

Limited work has been done to exploring the possibility of biological control for the sugarcane beetle. In 1930, Osterberger experimented with *Erax interruptus* (Diptera: Asilidae) (now *Triorla interrupta*) as a possible predator of the larval stage. Philips and Fox (1924) also noted mites (*Rhizoglyphus phylloxerae* Riley) on the beetles; these appeared to be detrimental to the immature stages and could possibly be implemented as a control measure.

The purpose of the current research project was to describe the biology and ecology of the sugarcane beetle in turfgrass. This beetle differs in overwintering and feeding behavior from other scarab turfgrass pests, thus it is essential to understand the basic biology of this beetle to optimize future control measures. Light trapping was used throughout the Raleigh, NC area to monitor adult presence and flight patterns. Dissections of spring and fall adults were conducted to determine the presence of eggs in the females. Beetles were kept in the laboratory after capture. Turfgrass choice and no-choice tests were conducted to discern if the adults have a habitat preference for cool or warm season turfgrasses.

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**Sugarcane Beetle (Coleoptera: Scarabaeidae) Flight Activity in North Carolina
Turfgrass**

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Abstract

The sugarcane beetle (*Euethola humilis*) has been known as a sporadic pest in numerous field crops since 1880. Recently, the sugarcane beetle was observed damaging turfgrass in North Carolina. The adult beetles are active at nighttime in the spring and fall, and both males and females are attracted to light sources. Black light traps were used to monitor spring emergence and presence of adult beetles. In 2009, 2010, and 2011 eight, five, and six light traps were placed, respectively, in Wake and Lee Counties in North Carolina. Traps were checked weekly from August through November (2009), March through December (2010), or May (2011). Following capture, beetles were either preserved in a freezer or were kept in the laboratory on a diet of apples and bermudagrass. Dissections were conducted on the abdomens of both sexes of the spring and fall populations to confirm beetle gender, and to document when the females harbored fully developed eggs.

KEY WORDS sugarcane beetle, flight activity, black light trapping, turfgrass

Introduction

The sugarcane beetle, *Euetheola humilis* (Burmeister), was initially named and described in 1856 by LeConte as *Euetheola rugiceps*. It was first considered a pest in 1880 when it was observed damaging sugarcane in Louisiana. It is unknown if *E. humilis* is indigenous to North America, but other *Euetheola* spp. are found in South America (Bernardi et al. 2008, Marques and Santana 2009). Only the adult is recognized as pestiferous (Baerg 1942, Philips and Fox 1924, Smith 2006). Sugarcane beetles, like some other scarabs, are nocturnal and attracted to artificial lights (White 1990).

The sugarcane beetle was first recorded damaging corn in 1888 by L.O. Howard in North Carolina and Mississippi (Philips and Fox 1924) and was consequently given the common name rough-headed corn stalk-beetle. Since then it has been a sporadic pest in the southern U.S. in sugarcane, corn, and rice (Baerg 1942, Philips and Fox 1924), and more recently in sweet potatoes (Smith 2006). Sugarcane beetles have also been documented damaging tobacco (Scott 1956), greenhouse roses (Lyle 1933), and strawberries (Baerg 1942) in isolated instances. The beetles have been observed in pastures in Arkansas and Louisiana (Philips and Fox 1924). Philips and Fox (1924) report that the sugarcane beetle feeds on grasses, particularly of the genus *Paspalum*. Baerg (1942) found evidence that the beetles can live on bermudagrass (*Cynodon dactylon*). However, there is no documentation of sugarcane beetles as pests of managed turfgrass.

When a new pest insect presents itself, a management plan is implemented to reduce loss to turfgrass. To develop a cost effective and environmentally sound pest management plan, the basic biology and ecology of the sugarcane beetle must be clearly elucidated. These

studies were conducted to describe the seasonal flight activity and presence of adult sugarcane beetles in North Carolina turfgrass and to determine oviposition timing.

Materials and Methods

In August 2009, four bucket light traps furnished with 22W, AC powered circular black light bulbs (#2851L BioQuip, Rancho Dominguez, CA) were placed at locations in Wake and Lee Counties, NC, to identify adult beetle seasonal flight activity. In September, two traps were placed in Wake County. Trap catches with lights suspended within two m of the ground did not differ from catches with black lights placed on the ground therefore both configurations were used (unpublished data). Light traps were checked weekly for the presence of sugarcane beetles.

One light trap (PF) was suspended one m above the ground from a tree at the North Carolina State University golf practice field in Raleigh NC (Wake County) (35.801166, -78.695094) July 21, 2009, next to a sloping putting green. In 2011, the PF trap was moved closer to the power source (maintenance building) where it was at ground level next to the putting green (35.800947, -78.694758).

Two light traps (WF#12 and WF#13) were hung one m above the ground from trees on August 24, 2009, at the Wakefield Plantation golf course on fairways 12 and 13 in Raleigh NC perpendicular to the fairways [(35.964374, -78.560678) and (35.963513, -78.558023) respectively].

A light trap (QR) was placed on a light post one m above the ground between a lake and a fairway(35.387437, -79.232893) July 22, 2009, at Quail Ridge golf course in Sanford NC (Lee County).

On September 13, 2009, a fifth trap (LW) was placed at the Lake Wheeler Turfgrass Research Station in Raleigh NC at ground level in the middle of 4 hectares of warm and cool season turfgrass blocks under irrigation (35.739224, -78.680309).

In September, 2009, the traps at Wakefield Plantation (WF#12 and WF#13) were moved from fairways 12 and 13 to 5 and 8 (WF#5 and WF#8) due to power source inconsistencies [(35.954214, -78.550313) and (35.954579, -78.557594) respectively]. Trap WF#5 was placed on the ground in the rough (native grasses) about six m from the fairway. Trap WF#8 was suspended one m above the ground from a tree within 15 m of the fairway. This trap was within a copse of coniferous trees, with one side facing the maintenance building.

A final trap (H) was hung one m above the ground from a tree at fairway 12 on September 16, 2009, at the Heritage golf course in Wake Forest NC (Wake County) (35.946038, -78.492541). This trap was surrounded on one side by trees and opened out to the tee box on the other side.

From August 26 through November 11, 2009, a light trap was placed at a home lawn in Cary NC (35.819095, -78.792954). Only six beetles were caught in Cary in 3 months, thus this trap was not included in the results. The lawn was treated with insecticides by the home owner.

In March, 2010, black light traps were again placed at PF, WF#5, WF#8, LW, and H. The fairways at Heritage golf course (H) were treated with imidacloprid on May 16, 2010. In March, 2011, all of the aforementioned sites were used, with the addition of a trap hung one m above the ground from a tree at the University Club workshop (Univ) in Raleigh, NC

(35.800398, -78.694769). This trap was surrounded by a building and trees on one side and opened up to the golf course and a newly dug pond on the other side.

By season, each week of beetle captures was calculated as a proportion of the total seasonal catch. In each season, the maximum beetles captured accounted for 30% of the total seasonal catch. Thus, any weeks that had a proportion greater than 15% of the whole season catch were considered to be a peak of adult flight activity. Weekly rainfall and average temperatures for each season are recorded in Tables 4-6 (State Climate Office of North Carolina archives).

Sugarcane beetles found in the light traps were collected weekly and counted. Beetles were either placed in a freezer in Ziploc® (SC Johnson, Racine, WI) bags or held in 15 L plastic bins with a mixture of peat/sand (3:2) (#11861882 Sterilite®, Townsend, MA) and apple slices (Forrest et al. 1995). The lids of the containers had a 7.6 cm x 12.7 cm hole cut in the top with plastic screen hot glued to cover the opening (Fig. 1) to prevent beetle escape. Beetles were kept for observation purposes as well as to maintain a population of adults for future experiments. Voucher specimens were prepared and placed in the North Carolina State University Insect Museum, Raleigh, NC.

Dissections were carried out on male and female adults from the fall 2010 and spring 2011 collections. After initial dissections it was discovered that beetles preserved in 70% ethanol were unsuitable for making internal observations, and that dead beetles desiccated too quickly to investigate internal structures. Thus, all beetles used in dissections were preserved by freezing live specimens. Using a dissection microscope, forceps were used to remove the elytra of the beetles, and the exoskeleton underneath was gently pulled away to

reveal the internal structures. Genitalia were investigated to confirm sex and presence of eggs in female beetles (Fig. 2). Twenty-three female beetles were dissected from each of the fall 2010 and spring 2011 collections.

Results

In fall 2009, 741 adult sugarcane beetles were trapped, with the largest number (n=471) captured in October. Three peaks of activity were observed, in weeks 10, 12, and 14 (Fig. 3). Trap H had the most beetles (n = 505) (Table 1). The last collection was November 20, 2009.

The first beetles in 2010 were collected April 4 (Table 2). Peak flight activity was observed in weeks 5 and 6 (Fig. 4). The most beetles were captured in May (n=4838), followed by a sharp decline through July, when only 44 beetles were caught. In fall 2010, there was no clear peak of beetle activity. Trap H captured the most beetles throughout the year (n = 4216).

The first beetles in 2011 were collected April 10 (Table 3). Adult beetle activity peaked in weeks 3 and 4 (Fig. 5). Trap H had the most beetles (n = 968).

In all three seasons, peak flight activity did not relate to seasonal high temperatures or rainfall events. In 2010 and 2011, temperatures the week prior to first beetle catch averaged 16.56 C and 15.0C, respectively (State Climate Office of North Carolina archives) which is consistent with Holman's (1968) findings.

All female beetles dissected in the fall of 2010 were found without eggs. Of female beetles dissected in the spring of 2011, 190 of 23 were found to have eggs. An average of 6 eggs was found within females bearing eggs, with a high of 16 eggs (Table 7). Baerg (1942)

reported that females may lay up to 100 eggs over her lifetime, which suggests that females produce multiple clutches of eggs. In April, 2011, beetles were found mating in the laboratory. The females were dissected, and eggs were developing.

During female dissections, two setose structures were observed at the posterior end of the abdomen. After comparison with other scarab females, it was determined that these structures were the inferior genital plates, which were described by Philips and Fox 1924 but not illustrated. Photographs of these plates are provided for clarification (Fig. 6). The male genitalia have been photographed to augment existing drawings provided by Philips and Fox 1924 (Fig. 7). In addition, photographs of the ventral side of the abdomen of both females and males are offered to illustrate the differentiation between the sexes (Fig. 8).

Discussion

Based on these light trapping data, the sugarcane beetle is univoltine in North Carolina. Adult beetles eclose in August through late September. Adults are active throughout the fall and there is a peak of flight activity around October. As temperatures decline, adults do not appear to fly, although they may still feed. It remains unclear what triggers hibernation or where they overwinter, however, it is reasonable to assume that they burrow below the frost line. Other scarab beetle grubs retreat below the frost line in North Carolina to overwinter (Brandenburg and Villani 1995). Also, with their powerful forelegs, the sugarcane beetle can easily dig several centimeters below ground in the heavy clay soils of the piedmont region of North Carolina. Beetles captured in light traps in the spring have clay soil attached to their exoskeletons.

In early to mid-April, beetles begin to emerge and feed. There is a peak of flight activity in April or May. Nighttime temperatures must be above 18° C (over 14° C for at least a week prior) for adults to emerge in the spring (Holman 1968). Mating begins shortly thereafter, and eggs are laid from May through July. Mating has been observed as early as April 28 in the laboratory. This extended egg laying period causes an overlap in the presence of eggs, larvae, and adults. A female can lay multiple clutches of eggs throughout her lifetime, with up to 100 total eggs laid (Baerg 1942). On average, 81-116 days are required for complete sugarcane beetle development, from egg to adult (Baerg and Palm 1932). After mating and egg-laying, male and female beetles continue to survive for 13-16 weeks. There is a gradual die-off of the adult population, with most beetles from the overwintering population dying off in July-August. Adult beetles are active aboveground from dusk until early morning and are attracted to lights.

Dissections indicate that the females do not develop eggs until the spring. Whether the female is fertilized before or after egg development is unknown.

Light trapping is a very efficient tool for monitoring the adult sugarcane beetle's activity. Future work on sugarcane beetles should concentrate on refining adult diurnal activity and discovering overwintering sites. Other monitoring techniques may be used to more efficiently find larval stages.

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Table 1. Summary of weekly light trap captures of adult sugarcane beetles by site for 2009

Site ¹	Week 1 July 26	Week 2 Aug 2	Week 3 Aug 9	Week 4 Aug 16	Week 5 Aug 23	Week 6 Aug 30	Week 7 Sept 6	Week 8 Sept 13
PF ²	--	--	--	4	7	15	5	5
WF#12	--	--	--	--	6	1	3	--
WF#13	--	--	--	--	22	0	3	--
WF#5	--	--	--	--	--	--	--	--
WF#8	--	--	--	--	--	--	--	--
QR	2	0	0	0	2	3	1	1
LW	--	--	--	--	--	--	--	--
H	--	--	--	--	--	--	--	--
Total	2	0	0	4	37	19	12	6

¹ PF, NCSU practice field; WF, Wakefield Plantation golf course followed by hole number; QR, Quail Ridge golf course; LW, Lake Wheeler Turfgrass Research Station; H, Heritage golf course

² From 8/17-9/21 three separate light traps were out at different heights. There was no difference in collection numbers, thus the totals have been combined

Table 1. (continued)

Site	Week 9 Sept 20	Week10 Sept 27	Week 11 Oct 4	Week 12 Oct 11	Week 13 Oct 18	Week 14 Oct 25	Week 15 Nov 1	Week 16 Nov 8
PF	2	0	0	2	0	7	1	0
WF#12	--	--	--	--	--	--	--	--
WF#13	--	--	--	--	--	--	--	--
WF#5	2	11	1	16	0	16	7	0
WF#8	0	27	4	9	0	1	5	0
QR	4	1	0	0	0	0	0	0
LW	3	19	3	2	0	1	1	0
H	3	88	40	123	1	241	0	0
Total	14	146	48	152	1	266	14	0

Table 1. (continued)

Site	Week 17 Nov 15	Total
PF	0	48
WF#12	--	10
WF#13	--	25
WF#5	0	53
WF#8	2	48
QR	0	14
LW	2	31
H	9	505
Total	13	734

Table 2. Summary of weekly light trap captures of adult sugarcane beetles by site for 2010

Site ³	Week 1 ⁴ Apr 4	Week 2 Apr 11	Week 3 Apr 18	Week 4 Apr 25	Week 5 May 2	Week 6 May 9	Week 7 May 16	Week 8 May 23
PF	3	2	2	32	0	7	14	8
WF#5	1	0	0	56	313	223	195	35
WF#8	9	3	1	1	262	46	66	245
LW	4	0	1	5	43	5	11	1
H	23	38	4	432	2142	1122	6	94
Total	40	43	8	599	2760	1403	292	383

³ PF, NCSU practice field; WF, Wakefield Plantation golf course followed by hole number; LW, Lake Wheeler Turfgrass Research Station; H, Heritage golf course

⁴ Light traps set out week of March 1; Week 1 beginning from first beetle capture

Table 2. (continued)

Site	Week 9 May 30	Week10 June 6	Week 11 June 13	Week 12 June 20	Week 13 June 27	Week 14 July 4	Week 15 July11	Week 16 July 18
PF	17	20	1	1	2	0	0	0
WF#5	34	8	4	0	0	0	0	0
WF#8	130	39	13	8	0	1	1	1
LW	1	18	88	58	38	6	24	2
H	11	17	6	5	11	2	2	1
Total	193	102	112	72	51	9	27	4

Site	Week 17 July 25	Week 18 Aug 1	Week 19 Aug 8	Week 20 Aug 15	Week 21 Aug 22	Week 22 Aug 29	Week 23 Sept 5	Week 24 Sept 12
PF	0	0	2	0	1	1	0	0
WF#5	0	4	17	21	8	3	2	0
WF#8	0	1	21	9	25	10	0	1
LW	3	1	8	22	4	21	2	5
H	1	4	26	62	25	20	13	7
Total	4	10	74	114	63	55	17	13

Table 2. (continued)

Site	Week 25 Sept 19	Week 26 ⁵ Sept 26	Week 27 Oct 3	Week 28 Oct 10	Week 29 Oct 17	Week 30 Oct 24	Week 31 Oct 31	Week 32 Nov 7
PF	0	--	0	0	0	1	0	0
WF#5	0	--	3	0	0	8	8	0
WF#8	4	--	8	1	0	11	9	1
LW	6	--	3	3	0	0	0	0
H	10	--	28	3	5	96	134	1
Total	20	--	42	7	5	116	151	2

Site	Week 33 Nov 14	Week 34 Nov 21	Week 35 Nov 28	Total
PF	0	0	0	114
WF#5	0	0	0	943
WF#8	0	0	0	1000
LW	0	0	1	384
H	0	0	0	4351
Total	0	0	1	6792

⁵ Heavy rains prevented trap collection

Table 3. Summary of weekly light trap captures of adult sugarcane beetles by site for 2011

Site ⁶	Week 1 ⁷ Apr 10	Week 2 Apr 17	Week 3 Apr 24	Week 4 May 1	Week 5 May 8	Week 6 May 15	Week 7 May 22	Week8 May 29	Total
PF	0	0	18	10	0	0	1	8	37
WF#5	0	8	41	24	3	8	16	6	106
WF#8	2	17	18	6	0	0	44	19	106
LW	0	5	17	2	0	72	12	110	218
H	2	56	563	258	27	0	62	--	968
Univ	0	0	5	3	0	1	10	16	35
Total	4	86	662	303	30	81	145	159	1470

⁶ PF, NCSU practice field; WF, Wakefield Plantation golf course followed by hole number; LW, Lake Wheeler Turfgrass Research Station; H, Heritage golf course; Univ, University Club

⁷ Light traps set out March 1 (PF, LW, and Univ) and March 9 (WF and H); Week 1 beginning from first beetle capture

Table 4. 2009 weekly rainfall and average temperatures. Values highlighted in blue indicate weeks of peak flight activity. Values highlighted in red indicate seasonal high.

Week	Date	Rainfall (cm)	Temperature (°C)
1	Jul 26	0.47	25.50
2	Aug 2	0.14	25.24
3	Aug 9	0.10	26.16
4	Aug 16	0.27	26.11
5	Aug 23	0.11	25.23
6	Aug 30	0.17	21.60
7	Sep 6	0.60	21.34
8	Sep 13	0.06	21.91
9	Sep 20	0.50	21.87
10	Sep 27	0.03	18.27
11	Oct 4	0.10	18.76
12	Oct 11	0.20	12.79
13	Oct 18	0.03	14.29
14	Oct 25	0.11	15.63
15	Nov 1	0.17	11.29
16	Nov 8	1.00	13.09
17	Nov 15	0.13	13.50

Table 5. 2010 weekly rainfall and average temperatures. Values highlighted in blue indicate weeks of peak flight activity. Values highlighted in red indicate seasonal high.

Week	Date	Rainfall (cm)	Temperature (°C)
1	Apr 4	0.36	19.97
2	Apr 11	0.00	16.40
3	Apr 18	0.13	14.79
4	Apr 25	0.10	18.09
5	May 2	0.01	24.33
6	May 9	0.00	20.23
7	May 16	0.97	19.23
8	May 23	1.11	22.14
9	May 30	0.61	24.44
10	Jun 6	0.19	24.81
11	Jun 13	0.17	26.79
12	Jun 20	0.10	27.87
13	Jun 27	0.01	25.16
14	Jul 4	0.01	27.67
15	Jul 11	0.26	26.86
16	Jul 18	0.00	29.06
17	Jul 25	0.50	26.93
18	Aug 1	0.50	25.81
19	Aug 8	0.03	27.70
20	Aug 15	0.37	26.79
21	Aug 22	1.53	24.40
22	Aug 29	0.00	25.49
23	Sep 5	0.01	22.71
24	Sep 12	0.01	24.11
25	Sep 19	0.00	25.06
26	Sep 26	2.19	20.13
27	Oct 3	0.00	15.44
28	Oct 10	0.17	17.87
29	Oct 17	0.01	15.26
30	Oct 24	0.11	18.14
31	Oct 31	0.19	10.47
32	Nov 7	0.00	10.09
33	Nov 14	0.09	11.04
34	Nov 21	0.01	11.93
35	Nov 28	0.03	6.66

Table 6. 2011 weekly rainfall and average temperatures. Values highlighted in blue indicate weeks of peak flight activity. Values highlighted in red indicate seasonal high.

Week	Date	Rainfall (cm)	Temperature (°C)
1	Apr 10	0.21	17.06
2	Apr 17	0.16	17.61
3	Apr 24	0.20	21.17
4	May 1	0.19	16.83
5	May 8	0.40	18.80
6	May 15	0.07	19.07
7	May 22	0.46	24.39
8	May 29	0.00	26.09

Table 7. Spring 2011 Adult female dissections

Date Collected	Location ⁸	Eggs Present
4/21	WF#5	0
4/21	H	0
4/27	LW	0
4/27	LW	3
4/27	LW	3
5/4	PF	5
5/4	PF	3
5/4	WF#8	6
5/12	H	4
5/12	H	0
5/12	H	5
5/18	WF#5	3
5/18	WF#5	9
5/18	LW	3
5/18	LW	9
5/18	LW	5
5/18	LW	5
5/18	LW	10
5/18	LW	8
6/1	LW	2
6/1	LW	7
6/1	LW	9
6/1	LW	16

⁸ PF, NCSU practice field; WF, Wakefield Plantation golf course followed by fairway number; LW, Lake Wheeler Turfgrass Research Station; H, Heritage golf course



Figure 1. Containers housing adult sugarcane beetles. A 3:2 peat: sand mixture was kept moist, and beetles were fed apples and turfgrass.

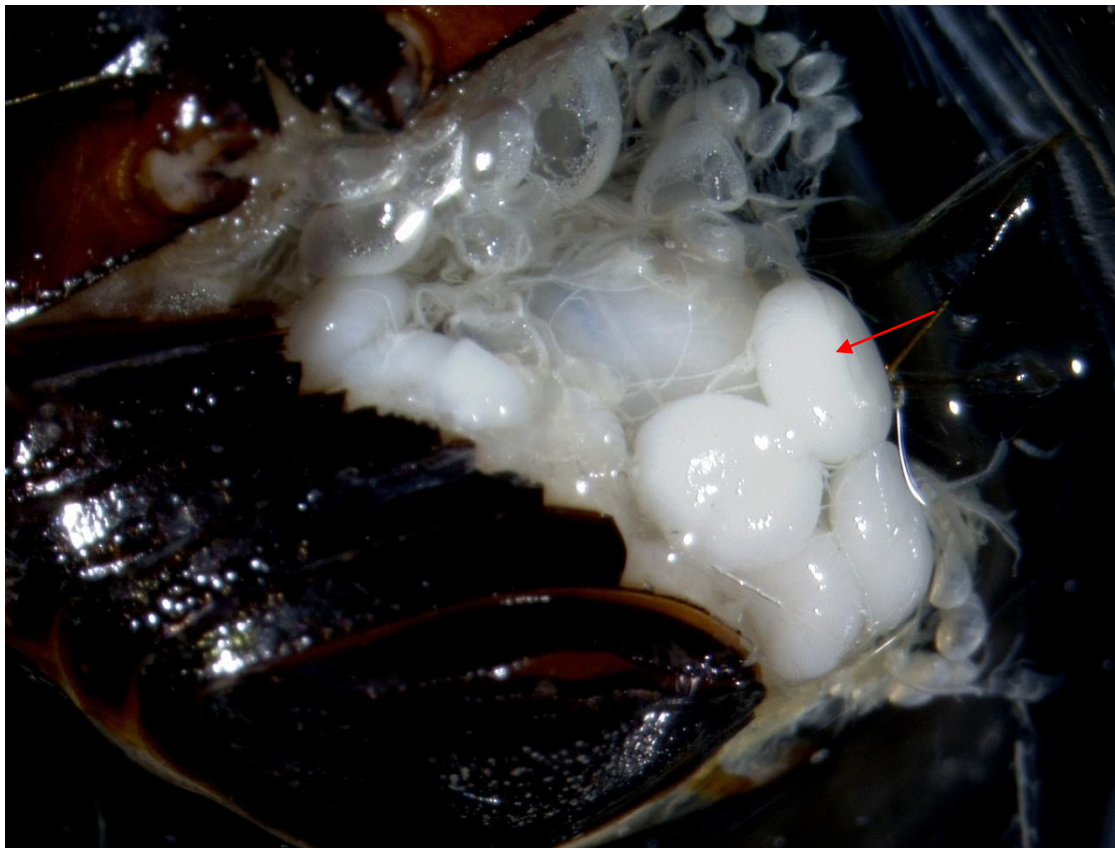


Figure 2. Female sugarcane beetle with eggs present.

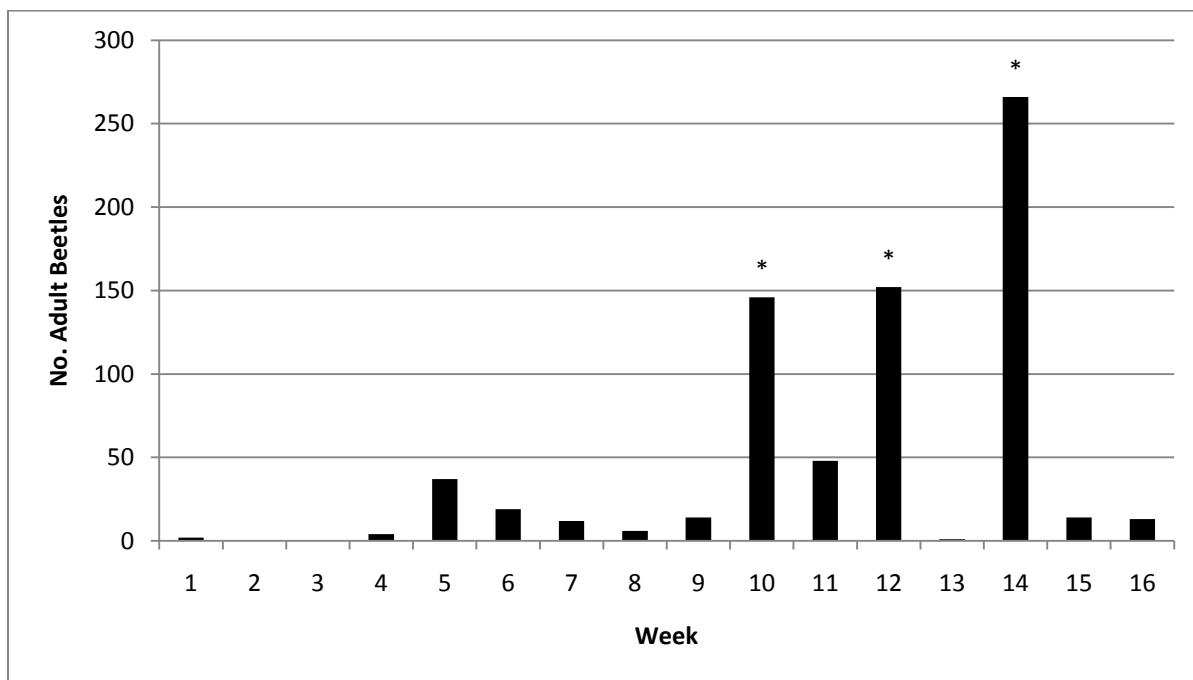


Figure 3. 2009 total beetles collected (8 locations).

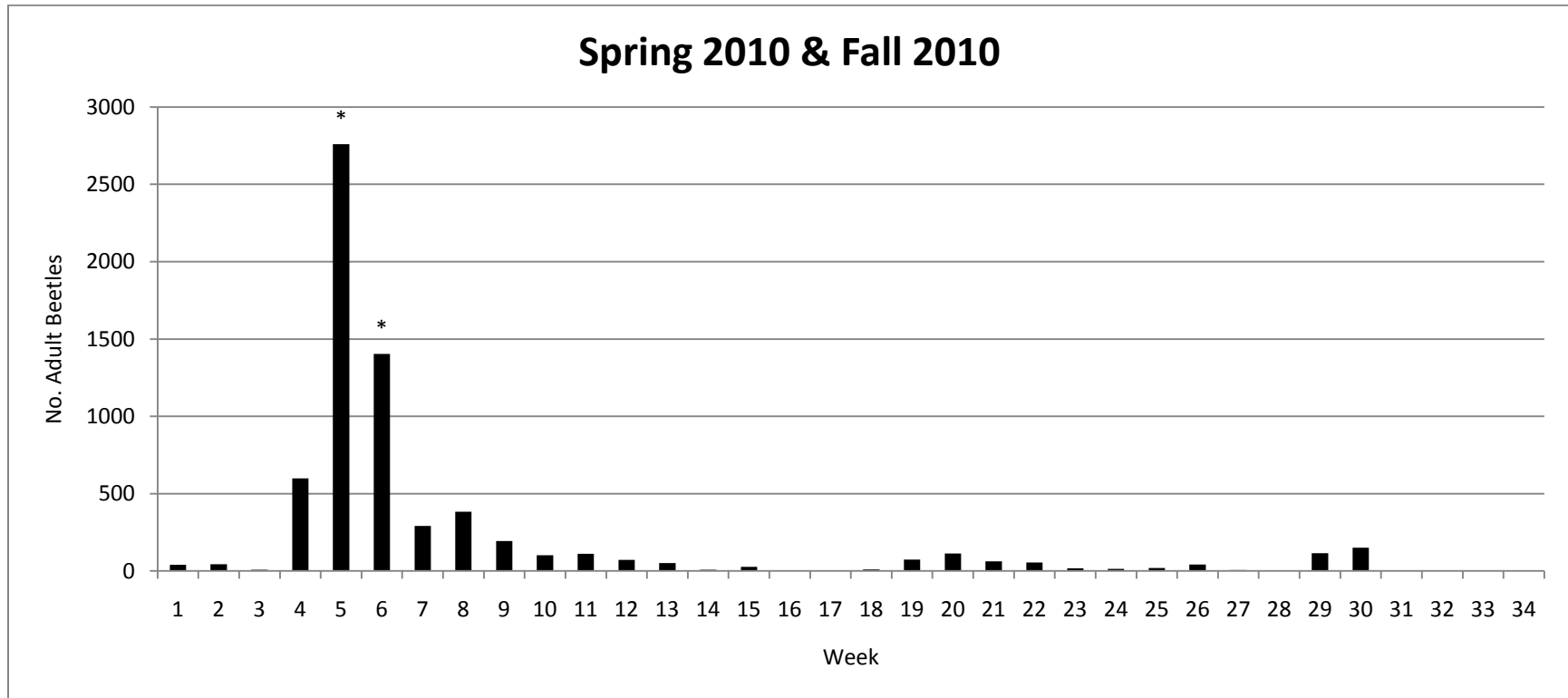


Figure 4. 2010 total beetles collected (5 locations).

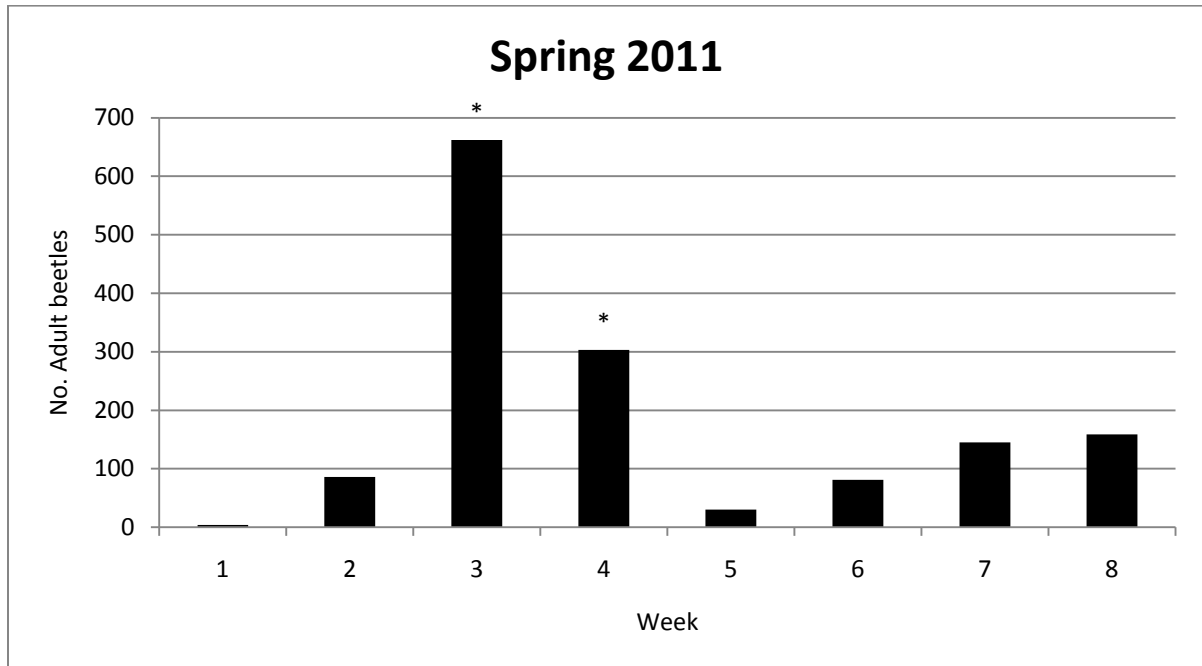


Figure 5. 2011 total beetles collected (6 locations).



Figure 6. Female genital plates, first described by Philips and Fox (1924).



Figure 7. Male genitalia of the sugarcane beetle.



Figure 8. Ventral side of the female (left) and male abdomens. Females have a more pointed posterior end.

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Sugarcane Beetle Turfgrass Species Habitat Preference
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Sugarcane Beetle (Coleoptera: Scarabaeidae) Turfgrass Species Habitat Preference

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Abstract

The sugarcane beetle (*Euethola humilis*) has been known as a sporadic pest in field crops since 1880. Our first observation of the sugarcane beetle in North Carolina turfgrass was about ten years ago. North Carolina is within a climate transition zone where cool and warm season turfgrasses are grown throughout the state. Historically the sugarcane beetle has been associated with warm season grasses, but it is not known whether they use cool season turfgrasses. In this study, small arena choice and no-choice tests were set up to evaluate adult beetle responses to tall fescue and bermudagrass habitats. Adult beetles were found in bermudagrass cores more than tall fescue (73%); however there were not enough data to make this statistically significant.

KEY WORDS sugarcane beetle, *Euethola humilis*, host selection, turfgrass

Introduction

The sugarcane beetle, *Euetheola humilis* (Burmeister), was first considered a pest in 1880 when it was observed damaging sugarcane in Louisiana. It is unknown if *E. humilis* is indigenous to North America, but other *Euetheola* spp. are found throughout South America (Bernardi et al. 2008, Marques and Santana 2009). Only the adult stage has been identified as pestiferous (Baerg 1942, Philips and Fox 1924, Smith 2006).

The sugarcane beetle was first recorded damaging corn in 1888 by L.O. Howard in North Carolina and Mississippi (Philips and Fox 1924) and was consequently given the common name rough-headed corn stalk-beetle. Since then it has been a sporadic pest in the southern states in sugarcane, corn, and rice (Baerg 1942, Philips and Fox 1924) and more recently in sweet potatoes (Smith 2006). Sugarcane beetles have also been documented damaging tobacco (Scott 1956), greenhouse roses (Lyle 1933), and strawberries (Baerg 1942) in isolated instances. In Brazil, it is a new pest of eucalyptus trees (Bernardi et al. 2008). There are also reports of beetles observed in pastures in Arkansas and Louisiana (Philips and Fox 1924). Philips and Fox (1924) report that the primary food source of the adults is grasses of the genus *Paspalum*: particularly *P. leave* and *P. plenipilum*. Baerg (1942) found evidence that the beetles can live on bermudagrass (*Cynodon dactylon*). However, there is no documentation of sugarcane beetles as pests of high quality turfgrass.

Both *Paspalum* spp. and bermudagrass are warm season turfgrasses. In North Carolina, sugarcane beetles have been documented feeding upon the warm season turfgrasses bermudagrass and zoysiagrass (personal observation). North Carolina is within a climate transition zone, where warm and cool season turfgrasses are often grown adjacent to one

another (Beard 1973). Many warm season turfgrass areas where sugarcane beetles have been observed are surrounded by or mixed with cool season grasses.

In North Carolina, tall fescue (*Festuca arundinacea*), bermudagrass (*C. dactylon*), and *Zoysia* spp. are the most common turfgrasses present (Brandenburg et al. 2004). Tall fescue is a cool season turfgrass, whereas bermudagrass and *Zoysia* are warm season species. The primary physiological difference between cool and warm season turfgrasses is how they fixate carbon.

Carbon fixation is the first step of photosynthesis. Cool season turfgrasses use a C₃ pathway where CO₂ is fixed to the Rubisco enzyme. This entire process is completed in the mesophyll cells and is most efficient with less lighting (Turgeon 2012). Cool season turfgrasses grow best when temperatures range from 16-24°C (Beard 2002). Warm season turfgrasses use a C₄ pathway in which CO₂ is transformed in the mesophyll cells before following the C₃ cycle in the bundle sheath cells. This pathway more efficiently delivers CO₂ to Rubisco (Turgeon 2012). Warm season grasses are able to complete carbon respiration with less water and grow best in temperatures ranging from 27-35°C (Beard 2002, Turgeon 2012).

Though C₄ carbon fixation is overall more efficient, C₃ carbon fixation is more efficient when temperatures are lower and there is less sunlight. This causes a seasonal difference in photosynthetic activity. Photosynthetically derived chemicals are the building blocks for plant growth, such as sugars (Turgeon 2012). Thus, C₄ and C₃ plants have seasonally different chemical properties.

Bermudagrass and tall fescue also have different physical properties. Tall fescue leaves are rough, with a low shoot density. Shoots originate from the crown (Beard 1973). Bermudagrass has a smooth leaf texture and high shoot density. Shoots originate from rhizomes and stolons (Beard 1973). These differing textures and visual cues may affect insect feeding and oviposition preference (Cohen, 2004).

We hypothesized that sugarcane beetles would prefer warm season turfgrasses based on historical observations of feeding on warm season grasses and their southern distribution. Adult sugarcane beetle activity is greatest in the spring and fall, when warm season turfgrasses are beginning to grow (spring) and are just entering dormancy (fall). To test this hypothesis, choice tests were conducted to explore a possible habitat preference between these two common warm and cool season turfgrass species.

Materials and Methods

Turfgrass small arena choice and no-choice tests were carried out following procedures used by Freeman (2010). The arenas were made from 5.7 L plastic rectangular containers (34.5 x 21.3 x 11.4cm) (Rubbermaid Fashion Clears™, Atlanta, GA). A 1.27 cm thick R3 Styrofoam floor (Dow, Midland, MI) was built into each arena. Openings were cut in the Styrofoam floor to hold two 0.71L (10.2 x 10.2 x 10.2 cm) plastic storage containers (Arrow Plastic, Elk Grove, IL) (Fig. 1). Turfgrass cores were taken from the Lake Wheeler Turfgrass Research Station in Raleigh NC (Wake County) [bermudagrass cv. Tifway 419, (35.739822, -78.680510); tall fescue var. Confederate (35.739911, -78.681001) coordinates]. A core of bermudagrass or tall fescue (approximately 10.16 cm diameter by 10.16 cm deep) was placed into either plastic storage container so the grass crowns were flush with the

Styrofoam floor. Five adult sugarcane beetles of random sex were placed between the two cores of turfgrass on the Styrofoam floor and allowed to disperse (Fig. 2). An inverted rectangular container was placed on top of the arena and secured with four binder clips (one on each side) to prevent beetle escape. The arenas were kept at the Lake Wheeler Turfgrass Research Station at room temperature (20-23° C) with a light: dark cycle of 14:10 (Fig. 3). For choice tests, one core of tall fescue and one core of bermudagrass were used. In no-choice tests, either two bermudagrass or two tall fescue cores were used. The no-choice tests were used to test for coincidental aggregation.

After two days, the cores were destructively sampled using a serrated knife to cut open the cores; beetle numbers in both cores were then recorded. Three replicates of each trial were performed during each experiment. In 2010, nine separate experiments were conducted from May 24 through July 1. Five additional experiments were conducted from August 26 to October 31, 2010. In 2011, nine experiments were conducted from April 29 to May 18.

Statistical analyses were performed using Statistical Analysis System version 9.1 program (SAS Institute 2003, Cary, NC). Proc GLIMMIX was used to model the probability of a beetle going to one core or another within the arena. In arenas with bermudagrass and tall fescue cores, the choice was bermudagrass (1) or tall fescue (0). In no-choice arenas, the choice was either “left” (0) or “right” (1). In statistical analyses, all variables were considered random effects.

Results

The spring 2010 trial used 130 beetles in choice tests, and 86 (66%) were found in bermudagrass cores. The fall 2010 trial placed 74 beetles in choice tests, and 51 (69%) were found in bermudagrass cores. The trial conducted in spring 2011 used 133 beetles, 108 (81%) were found in bermudagrass cores. The average mean of the probability that a beetle will “choose” bermudagrass over tall fescue is 0.7324 (90% CI: 0.4594-0.8981) ($p > 0.0664$). Because 0.5 falls within the confidence interval (indicating a 50% chance of being in one core or the other), there is no statistically significant evidence that an adult sugarcane beetle will choose bermudagrass over tall fescue. In bermudagrass no-choice tests, the overall mean was 0.4249 (90% CI: 0.3417-0.5125) ($p > 0.0884$). In tall fescue no-choice tests, the overall mean was 0.4553 (90% CI: 0.3717-0.5414) ($p > 0.2903$). There was no statistical significance between a beetle going “left” or “right” within no-choice arenas.

Discussion

Adult beetles did not appear to choose one species of grass over the other, although there was a definite trend for more beetles to move into bermudagrass cores (73%); this difference, however, was not statistically significant. These trials indicate that there is no clear sugarcane beetle habitat preference for bermudagrass over tall fescue. In the bermudagrass and tall fescue no-choice tests, “left” and “right” cores were equally chosen

Some coincidental aggregation may have occurred in the duration of these tests. Adult beetles were chosen at random and were not sexed before placing them into arenas. It is possible that male beetles may have been attracted to females rather than turfgrass cores. Other factors, such as soil compactness or other physical properties, may affect adult beetle

aggregation. Conducting separate trails with all female or all male beetles and increasing test replicates would decrease any coincidental aggregation.

This study was not designed determine what the adults were feeding upon, but rather made observations on initial turfgrass species selection. Sugarcane beetles have a wide host range, and this could include cool season grasses (Baerg 1942, Bernardi et al. 2008, Lyle 1933, Philips and Fox 1924, Scott 1956, Smith 2006). It appears that in this choice scenario, the beetles rapidly sought refuge in one of the cores. While numerically more beetles were found in the bermudagrass cores, there was no significant difference in the numbers found in either core type.

Eggs were found laid in both bermudagrass and tall fescue throughout the spring trials. While it is possible some eggs may have been in the turfgrass cores prior to transferring the cores into arenas, this is unlikely. An adult female was observed on June 15, 2010, ovipositing in tall fescue. It is possible that cool season grasses, like tall fescue, are suitable feeding and oviposition sites for adult and immature sugarcane beetles. Previous studies documented sugarcane beetle larvae feeding on decaying plant matter (Ingram and Bynum 1932, Philips and Fox 1917); therefore turfgrass species may not play an important role for the larvae. Also, cool season grasses are growing very slowly during warm summer months (Turgeon 2012) while the larvae are developing, which may result in more organic matter accumulation.

Additional turfgrass cores were taken on July 7, 2010, from fairway 6 at the Wakefield Plantation golf course in Raleigh, NC (35.955299, -78.552466). Several sugarcane

beetle larvae were found within the thatch layer. First, second, and third instars were found on this date, indicating variation in timing of oviposition (Fig. 4).

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pp.42-47.

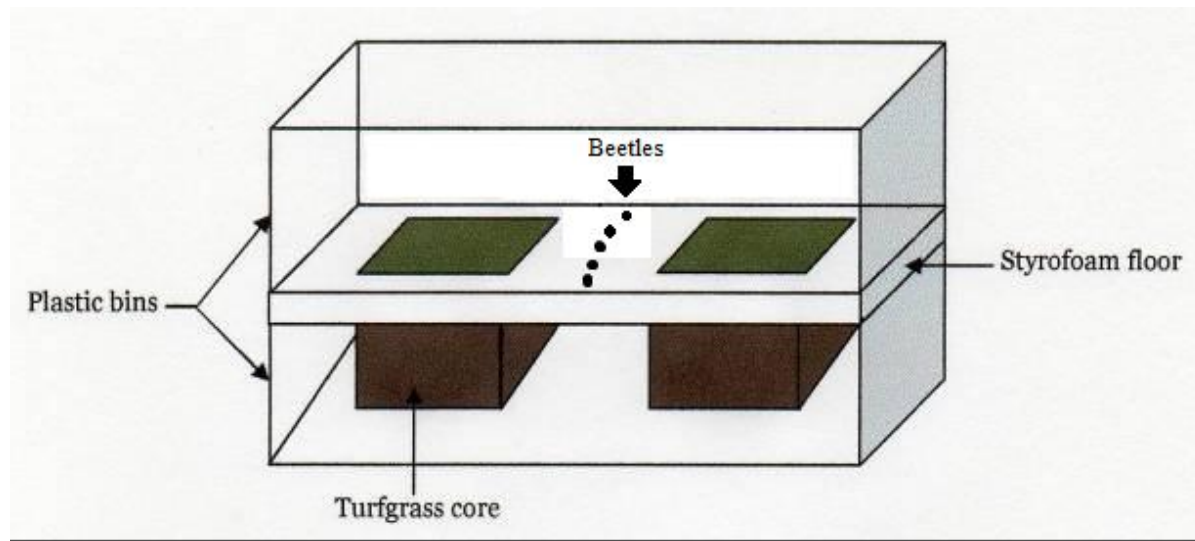


Figure 1. Configuration of choice and no-choice tests to evaluate adult beetle habitat preference.

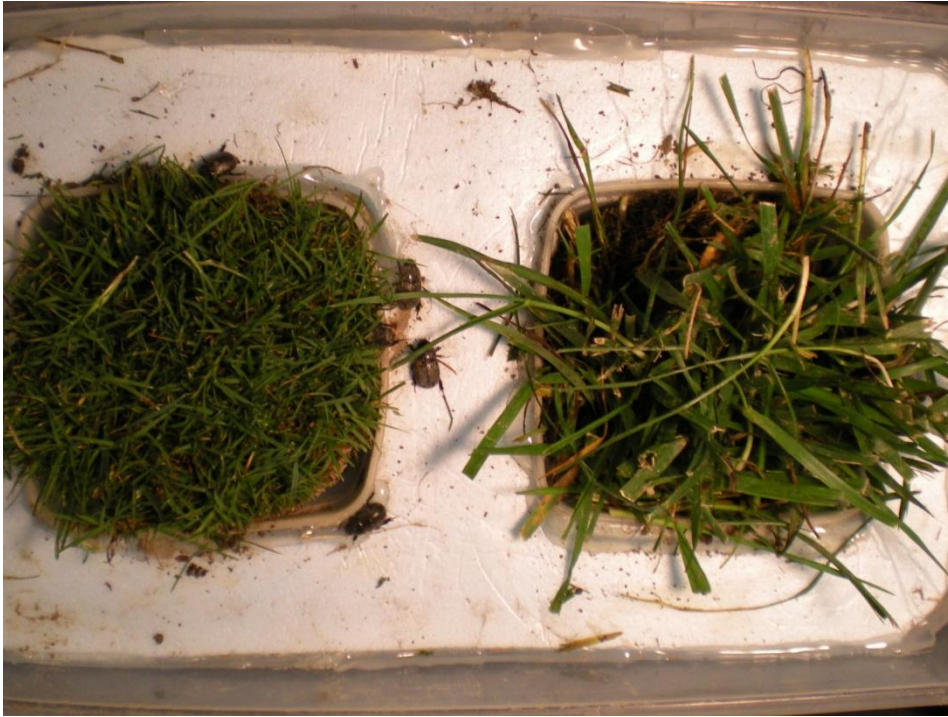


Figure 2. A core of bermudagrass (left) and a core of tall fescue used in a choice test for adult sugarcane beetles.

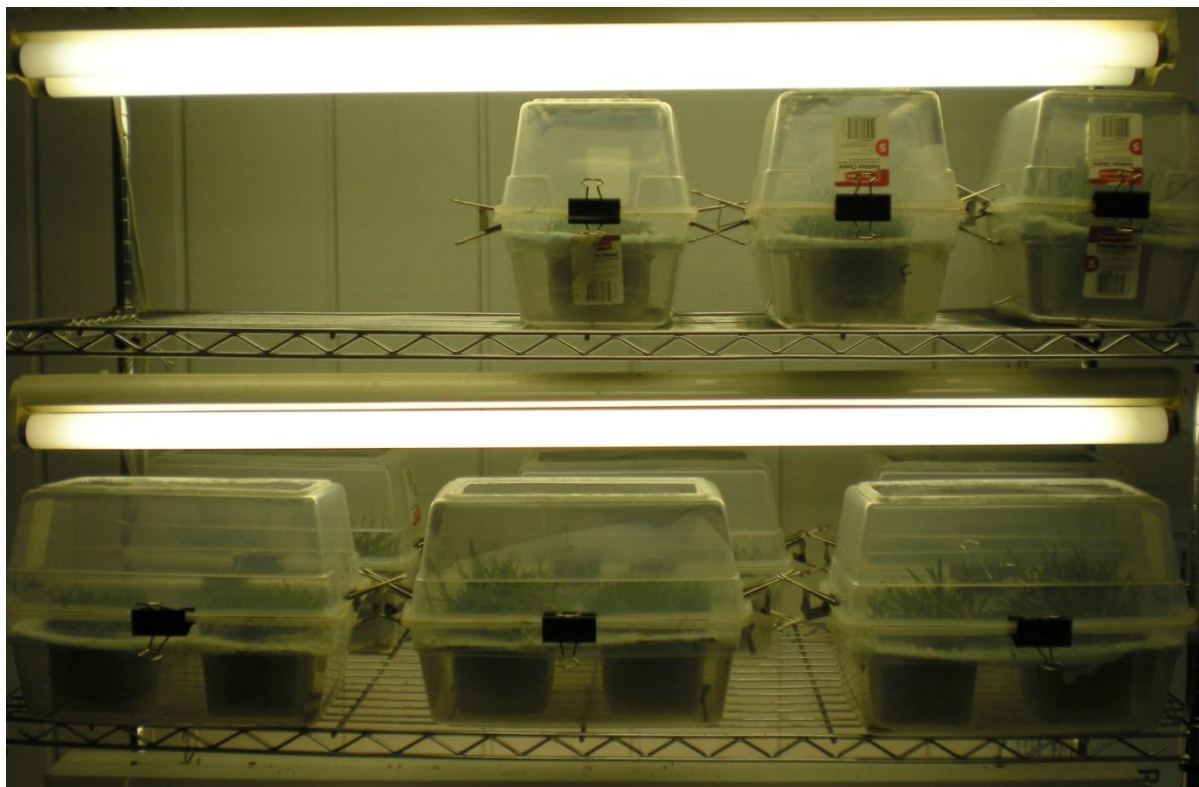


Figure 3. Choice test trials set up at the Lake Wheeler Turfgrass Research Station.



Figure 4. Third, first, and second stage sugarcane beetle larvae (from left to right).

APPENDICES

Murillo and Brandenburg:
Sugarcane Beetle Nightly Flight Activity
Using Timed Light Traps
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Appendix A
Sugarcane Beetle Nightly Flight Activity Using Timed Light Traps

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Introduction

The sugarcane beetle, *Euetheola humilis* (Burmeister), is an emerging pest of turfgrass. It was first considered a pest in 1880 when it was observed damaging sugarcane in Louisiana. Since then it has been considered a sporadic pest of various field crops including corn, sweet potatoes, and rice in the southern U.S. (Baerg 1942, Philips and Fox 1924, Smith 2006). The adults are nocturnal and attracted to lights (White 1990). Black light traps have been used to monitor adult flight activity. Light traps were used to discern the peak time of adult flight activity at night.

Materials and Methods

From August 2009 to May 2011, bucket light traps furnished with 22W, AC powered circular black light bulbs (#2851L BioQuip, Rancho Dominguez, CA) were operated at sites throughout Wake County, NC, to monitor beetles. In May, 2010, light trap power sources were plugged into one of three different types of timers (#TN311 Intermatic®, Spring Grove, IL; #TM01DHBL, Utilitech™, Lowe's, Wilkesboro, NC; #15119, General Electric Lighting, Fairfield, CT). The timers were plugged into AC power strips. All electrical cords and components were housed in 15L plastic containers (#008613, KIS, Milton, ON, Canada) for protection against adverse environmental conditions (Fig. 1). Two sets of four buckets each were used to capture beetles within four time blocks. Buckets (H) were placed at the Heritage golf course in Wake Forest NC (Wake County) (35.946038, -78.492541). These traps were placed on the ground on May 14, 2010. The area was surrounded on one side by trees and opened out to the tee box on the other side. Four traps (WF#5) were also placed at the Wakefield Plantation golf course in Raleigh, NC (Wake County) at fairway 5 (35.954214, -

78.550313). Traps were placed on the ground in the rough on May 19, 2010 about 6 m from the fairway. From May 16-18 the time intervals measured at H were: 8-9pm, 9-10pm, 10-11pm, and 11p-12am. This preliminary trial period revealed similar capture numbers, therefore time intervals were changed at H and WF#5 to: 8:30-10pm, 10-11:30pm, 11:30p-1am, and 1-2:30am. Traps were checked weekly through May 26, 2010. In May 2010, the average sunset was at 8:13 pm EST (Weather Underground Archives). The cumulative precipitation for Raleigh, NC, in May, 2010, was 12.7 cm.

Results

No clear patterns of adult flight activity were seen among time intervals or trap locations (Tables 1 and 2). However, there is a trend towards adult activity shortly after dusk at both locations.

Discussion

The results from the timed light trapping were inconclusive when trying to determine the time of flight activity at night, as a few late night trap catches prevented clear trends. Observations made by Holman (1968) suggested that beetles would be most active at dusk, though that was not always the case. In highly managed turfgrass, such as a golf course, factors such as irrigation may affect adult flight activity. Also, Holman showed that adult activity is highly temperature dependent. Turfgrasses most likely retain or conduct heat differently than field crops, thus affecting nighttime surface activity.

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Table 1. Adult beetle captures using timed light traps at Heritage golf course (H).

Date	Time Slot	Beetles
5/16/2010	8-9p	55
	9-10p	90
	10-11p	79
	11p-12a	38
5/18/2010	8-9p	1
	9-10p	2
	10-11p	2
	11p-12a	1
5/26/2010	8:30-10p	36
	10-11:30p	25
	11:30-1a	28
	1-2:30a	5
6/2/2010	8:30-10p	6
	10-11:30p	0
	11:30-1a	2
	1-2:30a	3
6/9/2010	8:30-10p	0
	10-11:30p	0
	11:30-1a	0
	1-2:30a	17
6/16/2010	8:30-10p	0
	10-11:30p	0
	11:30-1a	0
	1-2:30a	6

Table 2. Adult beetle captures using timed light traps at Wakefield Plantation (WF#5).

Date	Time Slot	Beetles
5/26/2010	8:30-10p	21
	10-11:30p	10
	11:30-1a	1
	1-2:30a	3
	6/2/2010	8:30-10p
	10-11:30p	13
	11:30-1a	9
	1-2:30a	0
	6/9/2010	8:30-10p
	10-11:30p	4
	11:30-1a	0
	1-2:30a	1
	6/16/2010	8:30-10p
	10-11:30p	0
	11:30-1a	0
	1-2:30a	2

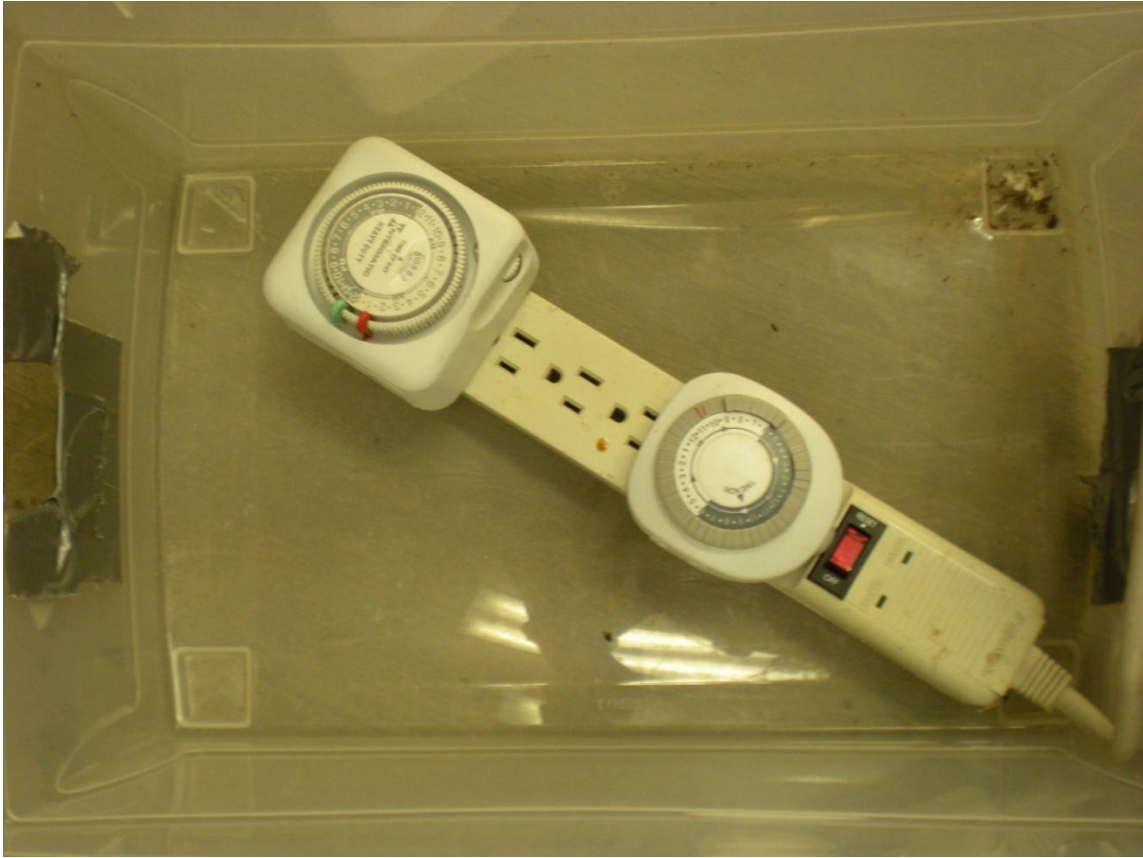


Figure 1. Plastic container housing electrical strip and light timers.

Murillo and Brandenburg:
Adult Sugarcane Beetle Flight Intercept Traps
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Appendix B

Adult Sugarcane Beetle Flight Intercept Traps

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Introduction

Sugarcane beetles, *Euetheola humilis* (Burmeister), are a known sporadic pest of field crops in the southeastern United States (Baerg 1942, Philips and Fox, Smith 2006). However, they are a growing threat to North Carolina turfgrass (Freeman 2010). Limited research has been conducted on this insect, and adult flight patterns or spatial distributions are poorly known. It remains unclear at what height above the ground adult beetles are flying. Seasonal or sexual cues may dictate when the adults are flying. It is also unknown to what linear distance the beetles may fly in a night. This could also affect the altitude at which the beetles fly, if beetles are flying long distances over variable terrain or plant life. The spatial or temporal patterns of flight of other scarab turfgrass pests have been documented (Stone, 1986). Though light traps have been used to monitor the adult flight activity of *E. humilis*, a method was developed to detect the altitude at which beetles fly.

Materials and Methods

Fifteen centimeter diameter polyvinyl chloride (PVC) piping was used to construct a frame to hold a 0.6 m by 1.8 m screen door. Frames were made to stand at 0.6 m, 1.2 m, and 1.8 m above the ground (Figs. 1-3). PVC pipe fittings (45° Wye and Tee connectors) were used to connect pipes together. Two PVC pipes cut to 0.6 m lengths had slits cut out of them with a table saw. This PVC “clamp” was used to hold the 0.6 m end of the screen. A PVC pipe cut in half across the diameter of the pipe was used as a trough to capture any beetles that flew into the trap and then fell down into the half pipe. The trough was filled with soapy water. All traps were camouflaged with “Hunter Green” spray paint.

Two traps of each height were set up at the North Carolina State University golf practice field in Raleigh NC (Wake County) around 7pm and were taken down the following morning around 7am. The traps were put up on the following dates: May 19, 2010; May 25, 2010; and June 1, 2010. Traps were put up randomly on the putting greens and in the rough. The practice field is an island of turfgrass surrounded by coniferous trees, and some traps were placed in the middle of the field and some at the borders. This site was chosen because of its secluded nature, to avoid vandalism and the ability to leave these large traps up overnight. During May, 2010, there was a peak of adult flight activity; however the practice field did not produce large numbers of captured beetles. After three nights without a single insect captured, a different approach was implemented. The traps of all heights were wrapped in Saran™ plastic wrap (S.C. Johnson & Son, Inc., Racine, WI) and then sprayed with Tangle-Trap Insect Trap Coating spray adhesive (Tanglefoot®, Contech Enterprises Inc., Victoria BC Canada) (Fig. 4). This modified trap was set up overnight on June 9, 2010.

Results

No insects were captured with the flight traps before the plastic wrap and Tanglefoot were used. The modified trap did capture one insect, a lady bird beetle (Coleoptera: Coccinellidae). Due to the lack of successful trapping, the flight intercept traps were not used again after this attempt.

Discussion

No sugarcane beetles were captured in the flight intercept traps. Adult beetles may not have been flying in this area the nights they were set up, or traps may not have been at heights or angles indicative of adult beetle flight. The traps may have been avoided by the

beetles despite the attempt at camouflaging them. The trap may have not effectively captured beetles even if they had flown into one of them.

It is known that adult sugarcane beetles will fly to artificial light sources when temperatures are above 18°C (Holman 1968, White 1990). Both females and males have been caught in bucket light traps in North Carolina turfgrass (See Chapter 1). However, little is known about the flight activity of adult sugarcane beetles relative to timing, distance, or height of flight. Future work on clarifying the flight patterns of male and females may lead to knowledge of diurnal resting places, and mating, oviposition, and overwintering sites.

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Figure 1. Flight intercept trap 0.6 m – 1.2 m above the ground.



Figure 2. Flight intercept trap 1.2 m – 1.8 m above the ground.



Figure 3. Flight intercept trap 0 – 0.6 m above the ground.



Figure 4. A 0.6 m – 1.2 m flight intercept trap wrapped in plastic wrap and sprayed with Tanglefoot®.

Murillo and Brandenburg:
Quantifying Sugarcane Beetle Damage
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Appendix C

Quantifying Sugarcane Beetle Damage in North Carolina Turfgrass

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Introduction

Sugarcane beetles, *Euetheola humilis* (Burmeister), are an emerging pest of managed turfgrass in North Carolina. Adult sugarcane beetles feed on and damage turfgrass and no management strategies currently exist (Freeman 2010). The beetles have been previously recognized as pests of agricultural crops such as sugarcane, corn, rice, and sweet potatoes (Baerg 1942, Philips and Fox 1924, Smith 2006). Agricultural management plans for this insect often focus on preventing infestation by cultural means, though some insecticidal studies have been conducted (Baerg 1942, Philips and Fox 1924, Riley 1986, Smith 2006).

Before any economical control methods can be established for the sugarcane beetle, an economic injury level (EIL) must be established. An EIL is the minimum number of insects that will cause economic injury to a commodity (Pedigo and Rice 2006). In the case of managed turfgrass, an EIL may more reflect the aesthetic qualities of turfgrass than the economic losses (Higley and Pedigo 1996). Based on an EIL, an economic threshold can be determined. An economic threshold relates to the density (usually) of insects that requires management (Pedigo and Rice 2006). A threshold is a tool used to determine if an insect is causing enough damage to warrant control. The purpose of this study was to determine a technique for measuring the threshold of damage for adult sugarcane beetles.

Materials and Methods

Beetles were collected using bucket light traps supplied with 22W, AC powered circular black light bulbs (#2851L BioQuip, Rancho Dominguez, CA). Traps were placed at locations throughout Raleigh, NC (Wake County) (See Chapter 1). Sugarcane beetles found in the light traps were collected weekly and counted. Beetles were held in 15.14 L plastic

bins with a mixture of peat/sand (3:2) (#11861882 Sterilite[®], Townsend, MA) and apple slices (Forrest et al. 1995).

Trials were conducted at the North Carolina State University Lake Wheeler Turf Research Facility, Raleigh, NC (Wake County). Five PVC arenas were driven into a plot of bermudagrass cv. Tifway 419, (35.739822, -78.680510) and one area of tall fescue var. Confederate (35.739911, -78.681001). The arenas were made from polyvinyl chloride (PVC) pipe (15 cm dia x 30 cm length). Arenas were driven into the soil until only 5-7 cm remained above the turfgrass (Dorskocil 2010) and were positioned in a straight row approximately 30 cm apart. On June 29, 2010, ten adult beetles were placed into each PVC arena, and plastic screen was placed over each circular opening and secured with 30 cm plastic cable ties (Figs. 1 and 2).

Beetles remained in the arenas for two weeks, with light irrigation (about 6.35 mm) every other day. After two weeks, the PVC arenas were removed from the surrounding soil to produce 10 large soil cores. The arena cores were destructively sampled to recover adult beetles using a serrated knife to cut apart the core.

Results

In the bermudagrass arenas, there was a 94% recovery rate of adult beetles. However, only 47% of beetles were alive. In the tall fescue arenas, 86% of beetles were recovered with only 28% alive (Table 1). Grass inside the PVC arenas was not visibly different from the grass surrounding the arenas, i.e. there was no visible damage caused by the sugarcane beetles.

Discussion

Overall, 90% of adult sugarcane beetles were recovered from the PVC arenas. Considering the strong, fossorial forelegs of the adults, this was surprising. It was originally hypothesized that the PVC arenas would need to extend deeper into the ground, but rocky soil conditions prevented such arenas. A high beetle recovery rate indicated that 30 cm long arenas would suffice in future studies.

The objective of this preliminary work was to determine if a specific number of beetles would damage turfgrass within these arenas. With 10 beetles per arena, no damage was visible. Future studies would increase beetle density.

It was anticipated that these trials could be repeated in the fall of 2010 and spring 2011, with an additional set of five PVC arenas in bermudagrass and tall fescue to serve as controls. Every week for at least four weeks a photograph of the arena (with the plastic screen removed) would be taken with the aid of a light box (Dosckosil 2010). The light box would regulate the lighting conditions. The photographs would be analyzed using Sigma Scan Pro (Systat Software Inc., San Jose, CA) digital imaging software. This software can quantify the amount of a color, such as green, thus it can be determine if the number of beetles per arena is affecting turfgrass quality. The number of beetles per arena can be extrapolated to determine a beetle: area ratio threshold for control. However, a significantly lower number of *live* beetles captured in fall 2010 prevented further trials from being conducted.

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(Coleoptera:Scarabaeidae) in Louisiana. *J. Agric. Entomol.* 7(2): 103-111.

Table 1. Sugarcane beetles adults recovered from PVC arenas. Percentage of recovered beetles is indicative of original 50 adult beetles placed total (10 per arena), and percent alive is based on how many beetles were alive from those recovered.

Grass Type	Arena	No. Recovered	No. Alive
Bermudagrass	1	9	2
	2	10	4
	3	9	6
	4	10	6
	5	9	4
Total		47	22
% Recovered		94.00%	
% Alive		46.81%	
Fescue	1	9	1
	2	9	3
	3	10	1
	4	8	4
	5	7	3
Total		43	12
% Recovered		86.00%	
% Alive		27.91%	



Figure 1. PVC arenas placed in bermudagrass at the Lake Wheeler Turfgrass Research Facility on June 29, 2010.



Figure 2. PVC arenas placed in tall fescue at the Lake Wheeler Turfgrass Research Facility on June 29, 2010.

Murillo and Brandenburg:
Determination of Adult Sugarcane Feeding
Sites on Two Types of Turfgrass
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Appendix D

Determination of Adult Sugarcane Beetle Feeding Sites on Two Types of Turfgrass

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Introduction

In North Carolina turfgrass, sugarcane beetles are an emerging insect pest (Freeman 2010). Historically, the sugarcane beetle has been a pest of agricultural crops (Baerg 1942, Philips and Fox 1924, Smith 2006). In sugarcane and corn, the adult beetle injures the plant by boring into the stalk of the plant just below the soil surface (Philips and Fox 1917). The beetles feed upon the fleshy roots of sweet potatoes (Smith 2006). While there are reports of the sugarcane beetle feeding upon *Paspalum* spp. and bermudagrass (*Cynodon dactylon*) there is no information on what specific part of the plant they damage (Baerg 1942, Philips and Fox 1924). The purpose of this study was to determine what part(s) of the turfgrass plant the adult beetles are feeding on by measuring the difference in weight of plant material before and after beetles were allowed to feed for one week.

Materials and Methods

Initially, eight beetles were starved for one week while eight additional beetles were allowed to feed freely upon apple slices. Beetles were transferred to the laboratory of Dr. Tom Rufty, Crop Science NCSU, for nitrogen content analysis by his Ph. D. student Shannon Sermons. Beetles were dried in a 45° C oven for 4 days in open crucibles. The weight of each individual beetle was measured. Five beetles from each treatment, distributed across the range of weights (to represent an overall average beetle size), were selected for nitrogen analysis. Each beetle was placed into a 7.5 mL plastic vial with four small steel balls, and then the vial was placed into a 2000 Geno/Grinder (Spex CertiPrep, Metuchen, NJ) for pulverizing. Samples were returned to the oven for further drying at 65° C, with repeated pulverizing on subsequent days until samples became powdery. Subsamples were weighed

into tin capsules, with one 2-mg and two 5-mg subsamples per beetle. Nitrogen concentration of the subsamples was determined using a Flash EA 1112C elemental analyzer (Thermo Finnigan, Ringoes, NJ). The nitrogen (N) content of these beetles was determined as baseline percentages (Table 1).

Separate trials were set up to measure the amount of each plant part fed upon by the adult beetles. Bermudagrass (*Cynodon dactylon*) and tall fescue (*Festuca arundinacea*) cores were collected (approximately 10.16 cm diameter by 10.16 cm deep) from the Lake Wheeler Turfgrass Research Station in Raleigh, NC (Wake County) [bermudagrass cv. Tifway 419, (35.739822, -78.680510); tall fescue var. Confederate (35.739911, -78.681001)].

In Trial 1, bermudagrass cores were destructively separated into roots and thatch (Fig. 1). Leaves were collected by mowing the grass and collecting the clippings. In Trials 2 and 3, bermudagrass samples were taken the same way, but stolons were also separated from the cores. In Trials 2 and 3, tall fescue samples were also used; tall fescue leaves were taken by mowing and collecting clippings. The thatch and roots were separated in tall fescue cores.

In Trial 1, approximately 80 g of each plant part was taken and placed individually into 946 ml plastic containers with air-tight plastic lids (REYRD232 Del-Pak®, Reynolds, Richmond, VA) (Fig. 2). Two replications each were set up for the leaves, thatch, and roots. Two adult beetles were weighed and placed in the plant material of each container. Trial 2 was set up the same way, except two 80 g replicates of bermudagrass stolon material were also used. Tall fescue in Trial 2 also used 80 g of each plant material type (Fig. 3). In Trial 3, 40g of each plant material type was used for all bermudagrass and tall fescue plant parts. Controls were used in Trial 2 and 3 and included containers of each plant material type for

bermudagrass and tall fescue. Plant material controls varied from approximately 13 g to 100 g of initial material. In Trial 3, controls also included six containers each with only two adult beetles.

All containers were maintained at the North Carolina State University Insectary at 27°C, 50% relative humidity, and a 13:11 light: dark cycle. After one week, the plant material and adult beetles were reweighed. The differences in weight can be seen in Tables 2-4. The beetle weights were averaged, so the difference in weights is a combined average.

Results

Starved beetles had an average of 12.3% nitrogen content while fed beetles only had an average of 8.9% nitrogen content. However, the average weight of the fed beetles was higher.

All beetles in containers with plant material were alive after one week regardless of what type of plant material was fed upon. All beetle controls (no plant material) were dead after one week. Plant material in all cases (except one) decreased in weight after one week. Averages of all the weight decreases are shown in Table 5.

Discussion

The nitrogen content of adult sugarcane beetles was measured in starved and fed beetles to establish a nitrogen content baseline. It was anticipated that this knowledge would be used in future studies. One such study would take N₁₅ enriched turfgrass cores and allow starved beetles to feed upon them. Each part of the plant (roots, stolons, etc.) absorbs a different concentration of the isotope (Bowman et al. 2002). Fed beetles can consequently be analyzed for N₁₅ content which would correspond to a specific plant part. However, before a

study of this magnitude could be conducted, it was necessary to test if adult beetles would feed on enough plant material for traceable amounts of the N_{15} isotope to be present. Basic plant material feeding studies were performed before any extensive nitrogen studies.

Plant material feeding experiments yielded a 100% survival rate by all adult beetles feeding on any of the plant material components for the duration of one week. All control beetles died after one week, either from desiccation or starvation. Beetles were not kept in the plant material longer than one week for fear of desiccation. In the plant material controls, the beetles lost weight in every instance (with one exception) after one week. Differences in plant material weight after one week were insignificant and inconsistent, and in some instances greater weight loss was observed in containers *without* beetles. Though the plastic containers were closed, weight loss (presumably water loss) still occurred. Therefore it is uncertain in replications containing beetles if any plant material weight loss was due to desiccation or to beetle feeding.

This method was dependent on significant differences in plant weight, but weight differences ranged from 3 g to less than 1 g. Measuring adult beetle mortality may be a better indicator of feeding behavior. Based on personal observations in the field, the author hypothesizes that the adults are feeding upon the roots and at the crowns of the turfgrass. However, further studies are necessary to clearly elucidate the feeding behavior of sugarcane beetles in both warm and cool season turfgrass. Knowledge of feeding sites and behavior may aid future efforts to control adult sugarcane beetles.

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Table 1. Nitrogen percentages of beetles starved for one week versus those allowed to feed freely on apple slices.

Starved Beetles		Fed Beetles	
Beetle Weight (g)	% Nitrogen	Beetle Weight (g)	% Nitrogen
72.03	12.51122	89.07	9.60843
82.58	12.21081	104.47	8.88721
57.58	12.09332	134.79	7.67239
68.70	12.27237	70.99	10.94974
66.00	12.30383	148.78	7.60907
average:	12.27831	average:	8.94537
std. error	0.06845	std. error	0.62716

Table 2. Trial 1: Differences in beetle (as a combined average) and plant material weight (g) after one week for bermudagrass only.

		Replicate	Weight Difference
Roots	Plant mat.	1	4.0694
		2	2.8453
Thatch	Plant mat.	1	1.95
		2	1.7548
Leaves	Plant mat.	1	2.624
		2	4.09

Table 3. Trial 2: Differences in beetle (as a combined average) and plant material weight (g) after one week for bermudagrass and tall fescue.

		Rep	Bermudagrass Difference	Tall Fescue Difference
Roots	Plant mat.	1	0.5672	1.5302
		2	0.617	1.0831
	Plant control	1	1.2785	0.6759
Stolons	Plant mat.	1	0.9541	--
		2	0.9206	--
	Plant control	1	1.1377	--
Thatch	Plant mat.	1	1.4819	1.4817
		2	1.7774	1.3046
	Plant control	1	1.2565	1.399
		2	1.8875	1.3774
Leaves	Plant mat.	1	2.8288	2.7857
		2	3.0348	2.866
	Plant control	1	1.6324	1.671
		2	3.136	2.5548

Table 4. Trial 3: Differences in beetle (as a combined average) and plant material weight (g) after one week for bermudagrass and tall fescue. Negative values indicated net growth.

		Rep	Bermudagrass Difference	Tall Fescue Difference
Roots	Plant mat.	1	0.8678	0.6581
		2	0.6342	0.9599
	Plant control	1	0.7718	0.903
		2	0.9041	0.882
		3	0.9513	0.683
		4	0.7345	0.746
		5	0.7306	0.684
		6	0.667	-1.492
Stolons	Plant mat.	1	0.9268	--
		2	0.9126	--
	Plant control	1	0.955	--
		2	0.856	--
		3	1.0045	--
		4	1.154	--
		5	0.7185	--
		6	0.8155	--
Thatch	Plant mat.	1	0.9736	1.3323
		2	1.2392	1.2997
	Plant control	1	1.091	1.4867
		2	1.0148	1.567
		3	1.086	1.243
		4	1.011	1.4972
		5	1.087	1.5485
		6	1.1517	1.33

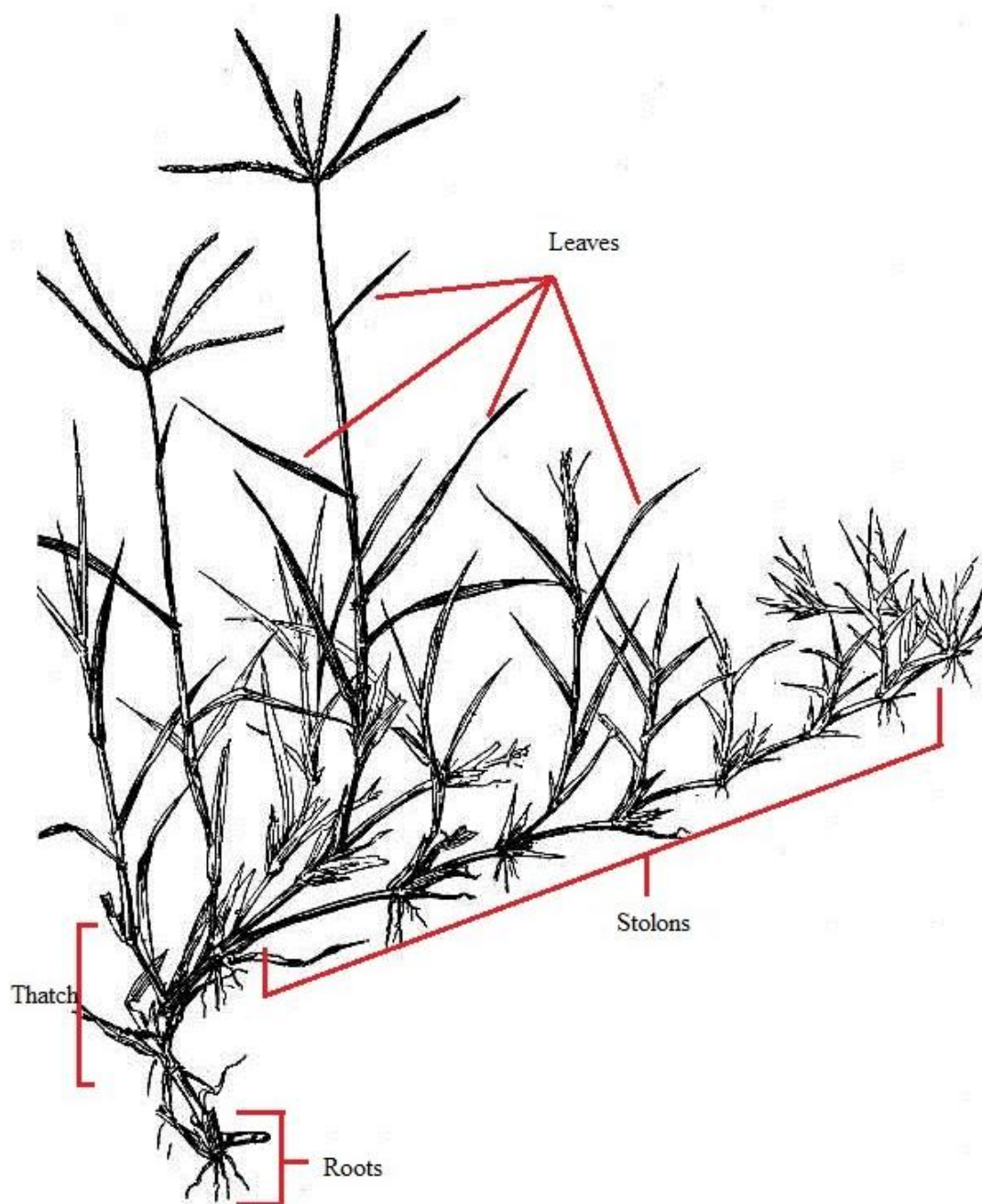
Table 4. (continued)

		Rep	Bermudagrass Difference	Tall Fescue Difference
Leaves	Plant mat.	1	1.6403	1.7769
		2	1.2724	1.4895
	Plant control	1	1.597	1.583
		2	1.819	1.481
		3	1.1265	1.396
		4	1.551	1.448
		5	1.529	1.578
		6	1.256	1.391

		Weight Difference	
Beetles Only	Control	1	0.2811
		2	0.2262
		3	0.1689
		4	0.175
		5	0.2299
		6	0.162

Table 5. Overall averages of plant material decreased (g) for each turfgrass type. Values shaded indicate instances where the control group lost more weight than containers with beetles.

Bermudagrass			Tall Fescue		
Roots	Plant mat.	1.42252	Roots	Plant mat.	1.057825
	Control	2.0717		Control	0.53845
Stolons	Plant mat.	0.928525	Thatch	Plant mat.	1.354575
	Control	1.02745		Control	1.4168
Thatch	Plant mat.	1.529483	Leaves	Plant mat.	2.229525
	Control	1.3228		Control	1.7962
Leaves	Plant mat.	2.58173			
	Control	1.932			



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Figure 1. A diagram of bermudagrass with labeled parts. These parts were separated for trials.



Figure 2. Bermudagrass plant material, clockwise from top left: leaves, roots, and stolons.



Figure 3. Tall fescue plant material: leaves

Murillo and Brandenburg:
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Appendix E

Monitoring Subterranean Adult and Immature Sugarcane Beetles

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Introduction

The flight of adult sugarcane beetles can be effectively monitored using bucket light traps. However, this method is not very practical for turfgrass managers, nor does it indicate subterranean populations. Two alternative monitoring techniques were investigated.

Adult sugarcane beetles spend the majority of their lives in the soil (Philips and Fox 1924). Two common techniques exist for flushing turfgrass pest insects to the soil turfgrass surface. Soapy water flushes (a 2% soapy water solution is poured over the soil surface) are effective for monitoring mole crickets, armyworms, chinch bugs, sod webworms, earwigs, and other soil dwelling insects (Shorter and Koehler 1979, Silcox 2011). Salt baths use a supersaturated salt solution to flush out insects, and have been used to flush annual bluegrass weevil (*Listronotus maculicollis*) larvae and adults (McGraw and Koppenhöfer 2008).

Materials and Methods

Beetles that were in bermudagrass (*Cynodon dactylon*) no-choice tubs (See Chapter 2) were used to test the flushing technique since a known number of beetles was present in each core. Approximately 1 L/77 cm² of a 2% solution of lemon-scented Joy dishwashing detergent (Procter and Gamble, Cincinnati, OH) was prepared and poured over four turfgrass cores. In four different bermudagrass cores, a supersaturated solution of Epsom salts was poured over each core at approximately 1 L/77 cm². After several minutes, each of the cores was destructively sampled using a serrated knife to look for beetles.

Results

After several minutes, no beetle activity occurred on the turfgrass surface with either flushing technique. After destructively sampling each turfgrass core, adult beetles were found

alive. Most of the beetles were found placid in the thatch of the bermudagrass. They had not moved toward or away from the soil surface after the soapy or salt water flushes.

Discussion

Soapy and salt water flushes work to flush insects to the soil surface by irritating the insect (Silcox 2011). No evidence of irritation or avoidance was observed with the adult sugarcane beetles, i.e. the beetles were not moving in the core. It may be that the beetles do not have external sensory organs which would detect the soap or salt water.

Soapy water flushes, of the same concentration, were also performed in the field, at the North Carolina State University golf practice field in Raleigh NC (Wake County) in spring 2010 on bermudagrass. This area was known to harbor sugarcane beetle populations, as indicated by bucket light traps (See Chapter 1). No beetles came to the soil surface.

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Murillo and Brandenburg:
An Unidentified Mite Found Within
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Appendix F

An Unidentified Mite Found Within an Adult Sugarcane Beetle

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Adult sugarcane beetles were collected for dissections using bucket black light traps (See Chapter 1). An adult female sugarcane beetle captured in a black light trap from the Lake Wheeler Turfgrass Research Station in Raleigh, NC on May 18, 2011, was dissected on June 12, 2011. While dissecting this female, a mite was found in the abdomen of the beetle. A mite (*Rhizoglyphus phylloxerae* Riley) has been associated with sugarcane beetle adults and larvae, but only externally (Philips and Fox 1924).

The mite was sent to the University of Arkansas, Department of Entomology for further identification. It was identified as *Macrocheles* sp. (Dermanyssina: Macrochelidae) by Michael Skvarla. Mites of this genus can be phoretic on insects, especially scarab beetles (Hartini et al. 2003). It is unknown how the mite was found within the beetle.

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