FACTORS INFLUENCING OCCURRENCE OF URBAN POLLINATOR, BENEFICIAL INSECT, AND BUTTERFLY POPULATIONS

By

BETHANY A. HARRIS

(Under the Direction of S. Kristine Braman)

Abstract

Insects provide ecosystem services such as pollination, biological control, and decomposition. Positive perception of beneficial arthropods is essential to public acceptance. Survey responses indicate amount of entomology education and demographics influence attitudes toward arthropods. Insect visitation was surveyed through visual observations and multiple trapping methods indicating occurrences of long-legged flies (F: Dolichopodidae), small bees, parasitic Hymenoptera, and predatory plant bugs (F: Miridae) in the Butterfly and Conservation Garden on the UGA Griffin Campus. Favored floral resources included Anise Hyssop 'Black Adder' (*Agastache* (Pursh) Kuntze 'Black Adder'), Coleus Fuseables (*Solenostemon scutellariodes* L.), and Gaura 'Passionate Blush' (*Gaura lindheimeri* Engelm 'Passionate Blush'). Lantana lace bug (*Teleonemia scrupulosa* Stål) may cause damage and influence beneficial insect visitation. Successful control of *Teleonemia scrupulosa* with limited effects on pollinating Lepidoptera and Hymenoptera such as *Junonia coenia* Hübner may be achieved through the use of alternative insecticides.

INDEX WORDS: Pollinating arthropods, Beneficial arthropods, ornamental plants, arthropod public perception, demographics, *Teleonemia scrupulosa* Stål

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DEDICATION

I dedicate this work to the good Lord who has directed my steps and so graciously provided every opportunity, placing so many valuable people in my life to help me accomplish my goals. “All praise to God, the Father of our Lord Jesus Christ. God is our merciful Father and the source of all comfort” (2 Corinthians 1:3, New International Version of the Bible).

I also dedicate this thesis to my wonderful parents, Clay and Debra Harris, who have supported me throughout the process. You both have always been a source of encouragement and support and been a reflection of Christ’s love. This work is also dedicated to my brother, Jordan who has been a constant friend and is always there to encourage and joke with me. A special feeling of gratitude to my friends and church family who have been there for me throughout my entire master’s program. All of you have been my best cheerleaders.

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

It is evident that insects contribute arthropod-mediated ecosystem services (AMES) such as pollination and biological control that are essential in every aspect of life (Rufus et al. 2009). In fact, pollinators are necessary for 35 percent of global crop production and 60-80 percent of wild plant species require pollination by animals or arthropods (Klein et al. 2007). Other AMES that insects participate in is the regulation of pests by natural enemies. Insect pests affect human activity as well as ornamental and agricultural production**,** with 37 percent of agricultural crops destroyed annually in the United States (Pimentel et al. 2001). Globally, more than $30 billion is spent annually on pest control with insecticides accounting for one-third of this amount (Rufus et al. 2009).

Although insects play an important role in our environment and in daily life, often insects are perceived poorly. Through a study by the ZHAW Zurich University of Applied Sciences, researchers found that butterflies, birds, and most mammals are highly appreciated when compared to reptiles, other insects (excl. butterflies), and amphibians (Schlegel et al 2010). One cause of this could be linked to aesthetics or physical attractiveness. Stanford Environmental Law Society (2001) states, "It is easier to justify the preservation of aesthetically-pleasing species than non-aesthetically pleasing ones". Negativistic attitudes, often fear or disgust, can also have an effect on how an insect is perceived. Metrick and Weitzman (1998) suggested "the utility of each species/library will be measured as a combination of commercial, recreational, and, yes emotional reaction to a given species". Nonetheless, age, level of education, and gender can influence attitudes toward insects.

"Habitat management" refers to intentionally attracting insects to garden areas and urban landscapes through the use of insect-attracting plant species. This concept was created to boost specific ecosystem services (Landis et al. 2000). By creating a habitat management site filled with native and exotic ornamental plants along with other insect-attracting plants, there can be potential increases in beneficial arthropod diversity, ultimately contributing to improved pollination and quality biological control. In fact, increasing evidence suggests that landscape composition directly affects beneficial insect populations and ecosystem services provided.

When attracting natural enemies to an area filled with food sources and overwintering sites, problematic insect pests will most likely be found. One common insect pest found on *Lantana* varieties is the lantana lacebug, *Teleonemia scrupulosa* (Stål) Feeding damage by *Teleonemia scrupulosa* (Stål) ultimately prevents lantana from blooming or will cause reduced blooming (Townsend et al.1999). Therefore, it is important to assess commercially-available standard and alternative insecticides for their effect on butterflies and suppression of common pests such as lantana lace bugs (*Teleonemia scrupulosa*). Utilizing marketed insecticidal soaps and natural products that can be used to limit pests without harming butterflies can provide options for the home horticulturists and pest management practitioners (Hall and Richardson 2012).

"Habitat management" employs the use of floral resources in managed areas to achieve ecosystem services (Fiedler and Landis 2008). When comparing this technique with other forms of pest management, habitat management is very distinct, providing directly or producing other ecosystem services that humanity desires. These include beautification, wastewater treatment, weed suppression, and conservation of biodiversity while increasing natural enemy populations (Fiedler and Landis 2008). Natural enemies are given alternate hosts, shelter, and non-host food such as nectar and pollen through habitat management that can ultimately lead to enhanced biological control (Fiedler and Landis 2007a).

In fact, previous research found parasitoids and predators benefit from non-host food. For species of parasitoids that do not participate in host feeding, nectar and pollen can be essential for the survival of adults (Jervis and Kidd 1986). Laboratory studies have shown that adult parasitoids which feed on nectar or sugar have a longer life span and increased reproduction (Dyer and Landis 1996, Baggen et al. 1999, Wäckers 1999). Predators may also feed on plant resources rather than prey, including pollen (Harmon et al. 2000) and phloem fluids (Eubanks and Denno 1999). Flower pollen proteins may be used to mature eggs with increased fertility seen in predators that have access to pollen (Hickman and Wratten 1996).

To have a successful habitat management site, it is crucial to increase pest suppression by providing natural enemies with adequate resources (Fiedler and Landis 2009). This can be achieved by choosing appropriate plant and floral resources to be established in the managed area. Some criteria used to determine which plants to choose for habitat management include: attractiveness to natural enemies, rich production of pollen and nectar, seed accessibility, availability of floral resources, flowering phenology, and plant adaptability (Fiedler and Landis 2007b). To increase the survival and reproduction of beneficial insect communities, pollen and nectar resources must be made available that are often in limited supply in modern agricultural landscapes (Fiedler and Landis 2007a).

In past research, use of floral plants to attract arthropods to habitat management sites has been limited to annuals and biennials that are not native to the area planted (Fiedler and Landis 2007a). These plants require yearly or biyearly plantings, and some of these species can become invasive. To avoid these problems, native perennial plants can be used (Fiedler and Landis 2007a). Several attributes that make these plants preferred choices for habitat management sites include local adaptation, increased native plant diversity, minimized recurring costs, and habitat permanency (Rufus et al. 2009). Few native plant species have reduced water, nutrient, and sometimes pest control requirements because of their adaptation to the climate in their localized region (Fiedler and Landis 2007a). Due to the conversion of land to agriculture, there has been a reduction of native plant species in areas with agriculture so by replanting and building native plant communities, ecosystem restoration can be attained (Fiedler and Landis 2007b). By choosing native perennials, cost and planting is minimized because established, plants can reseed themselves for years. Year-round arthropod resources can be provided through the use of native perennials (Fiedler and Landis 2007a).

However, research findings express some disadvantages of native perennial use that must be discussed. Some of these include: expense of native seed, unavailability of native seed for commercial use, and longer establishment period than annuals ultimately leading to less flower production in the first planting years (Rufus et al. 2009). Nevertheless, if native plant demand increased, the market would decrease these limitations. Also, expense of native perennials can be compensated for by the plant's long-life span (Rufus et al. 2009).

In order to prevent natural enemy mortality but reduce pests that may damage and prevent flowering of perennials in habitat management sites, available standard and alternative insecticides may be used. Products needing further evaluation include insecticidal soaps and oils and standard systematic insecticides that can be purchased directly. Insecticidal soaps can be safer for hard-bodied insects such as lady beetles when compared to standard insecticides (Hall and Richardson 2012). However, soaps may kill parasitoids (Weinzierl 2000; Tremblay et al. 2008). These soaps are labeled for homeowners and studies show insecticidal soaps provide significant, but short-term, insect pest control of the crape myrtle aphid [*Tinocallis kahawaluokalani* (Kirkaldy)] (Layton and Gu 2009a); greenbug [*Schizaphis graminum* (Rondanni)] (Nuessly and Nagata 2005); sweetpotato whitefly [*Bemisia tabaci* (Gennadius)] (Layton and Gu 2009b); the weeping fig thrips [*Gynaikothrips uzeli* (Zimmerman)] (Held et al. 2007); and the azalea lace bug [*Stephanitis pyrioides* (Scott)] (Nair and Braman 2012). Evaluations of insecticidal soaps for control of these pests were made after infested plants were directly sprayed in field experiments.

The lantana lacebug, *Teleonemia scrupulosa,* is a pest causing damage to Lantana, a popular landscape ornamental used in summer beds and valued for its floriferousness and drought tolerance, among others. There are 15 plant species, mainly *Lantana* and *Leucophyllum* spp., which have been reported as *Teleonemia scrupulosa* hosts (Harley and Kassulke 1971). *Teleonemia scrupulosa* feed on the ends of the leaves and on young flower buds of lantana, ultimately preventing blooming or causing reduced blooming

(Townsend et al. 1999). Signs of *Teleonemia scrupulosa* include: white-spotted leaves which resemble mite damage, brown spots (insect frass) on the underside of the leaves, and immature “skins” which may be found underneath the leaves (Johnson and Lyon 1991). In severe cases, *Lantana* spp. cultivars may lose their leaves or foliage may become white in color (Habeck 2001). To prevent or significantly reduce *Teleonemia scrupulosa* damage to *Lantana* spp. varieties without harming beneficial insects and butterflies that often utilize lantana as a floral resource, available standard and alternative insecticides may be used. However, insufficient information is known about the use of these products and their control success rates of *Teleonemia scrupulosa*.

Humans most often have negative attitudes toward insects and their role in the environment. However, insects act as pollinators, biological control agents, and foragers influencing agricultural production. Several factors may cause these negative feelings, including aesthetic attitudes. Aesthetics or physical attractiveness may affect people’s opinion of insects (Knight 2007). Research by Kellert (1989,1993,1996), hypothesized that aesthetic attitudes positively affect public support of arthropod species. For instance, if a species is seen as “cute” or having beauty, it will have increased levels of support. However, a nationwide U.S. mail survey to the general public was performed in 1994, suggesting physical attractiveness did not influence public support or acceptance of animal and arthropod species surveyed (Czech et al. 1998).

Negativistic attitudes, feelings of fear or disgust towards insects can impede conservation efforts (Knight 2007). For example, if a person has been stung or bitten by an insect, there will be negative perceptions towards potential pollinators. Although, Czech and Krausman (2001) believe that while people may have negative attitudes toward insects, these attitudes do not dominate how people perceive arthropod species. However, Kellert (1989, 1993) found that negativistic attitudes or fear of species translates to the overall perception of the species. Other studies state that there is "significance of perceived danger in environmental preferences" and suggest negativistic attitudes contribute to negative support of a species. (Herzog and Kutzli 2002).

Other factors that influence an urban population's perception of arthropods include age, gender, environmental education level, and occupation. Although more research is needed to verify if such factors have an effect on arthropod-related attitudes, a study conducted by the Norwegian Institute for Nature Research surveyed resident's attitudes towards common urban animals and found females preferred the popular and neutral species, while males chose the less-preferred species (Bjerke and Østdahl 2004). In another study, preference scores for birds of prey, bumblebees, bats, beetles, snails, wasps, and bees were higher in men; women had higher scores than men for well-liked species including mammals, birds, and butterflies and lower scores than men for less-liked species such as other insects, amphibians, and reptiles (Schlegel et al. 2010).

Also, education was significant in 17 of the 24 groups of species with higher preference scores for "unappealing species" by individuals which had higher levels of education. Age played a role in 14 of the 24 groups with small birds, butterflies, magpies, bumblebees, seagulls, wasps, and bees positively associated with age of survey respondents (Bjerke and Østdahl 2004). Research at Yale University, School of Forestry and Environmental Studies, residents assessed the general public, farmers, scientists, and conservation organization members in Connecticut. The general public and farmers were found to regard most invertebrates, mainly arthropods, with fear, avoidance, unawareness, nervousness, and repulsion (Kellert 1993). However, scientists portrayed invertebrates more positively, with slightly reduced perceptions by conservation organization members.

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CHAPTER 2

OPPORTUNITY TO IMPROVE PUBLIC PERCEPTION OF ARTHROPODS AND ARTHROPOD-RELATED BENEFITS

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ABSTRACT Use of insecticides can pose risks for pollinating and beneficial arthropods. The general public may not recognize the value of conserving these arthropods in their garden or home landscape. A survey was conducted using nine common insects and one spider species that were collected in the Butterfly and Conservation Garden located on the University of Georgia Griffin Campus, Research and Education Garden. Each of the 75 survey participants was asked to rank arthropods from most to least appealing and whether attitudes changed toward the insect ranked least appealing after knowing the benefits. Age, gender, and amount of Entomology education were also recorded for each survey respondent. A Gulf Fritillary (F: Nymphalidae) and an Eastern Swallowtail (F: Papilionidae) were the most appealing while a wolf spider (F: Lycosidae) was considered least appealing. Amount of Entomology education largely impacted respondent's perception of arthropods. A majority (60%) of the respondents were willing to change their attitudes about the insect ranked least appealing after learning about its benefits.

KEY WORDS Survey, Beneficial arthropods, Pollinating arthropods, Public perception, , Entomology education

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The general public frequently has negative feelings when asked about insects. However, insects provide vital ecosystem services such as pollination, biological control, and foraging (Kellert 1996). These creatures provide services that positively affect the environment and quality of life. Although not commonly referred to as the 'little things that run the world', insects are important components of the food web as well (Hunter 2008). Studies show butterflies, birds, and most mammals are highly perceived when compared to reptiles, other insects, and amphibians (Stanford Environmental Law Society 2001). This could be due to aesthetics and negativistic attitudes (Kellert 1989). Negativistic attitudes that influence the public's perception of insects include fear, disgust, and their status as pests (Kellert 1993). However, the proportion of insects that are considered pests is very small when compared to insects that are not deemed pests. Aesthetics also plays a role in how arthropods are perceived (Knight 2007).

Aside from negativistic attitudes, demographics such as age, gender, and education may also contribute to positive and negative perceptions of arthropods. Bjerke et al. (1998) determined that interests in wildlife decreased with increasing age, and few respondents wished to save ecologically-significant species (ants, bees, ladybirds) from extinction. When assessing the "degree of preference for various animal species", gender played a role with girls preferring horses and pet animals while boys preferred wild animals (Bjerke and Østdahl 2004). In a recent study, attitudes towards spiders and the level of knowledge of spiders were compared in high school students from Slovakia and South Africa. In South Africa "Biology teaching is based on ecosystems" and in Slovakia, "systematic zoology and botany" is primarily taught (Prokop et al. 2010). A statistically significant but low correlation between knowledge and attitude was found among the Slovakian students.

One growing challenge is to promote conservation and importance of insects in urban, suburban, and exurban locations where insects are commonly encountered. In fact, 50% of the world's population lives in urban cities and this is expected to rise to 66% in the next 20 years (Hunter 2008). There are a variety of different management practices that can be implemented by the public to promote conservation of pollinators and beneficial insects (Meena 2012). This includes limiting pesticide and herbicide inputs that may negatively affect beneficial insects (Meena 2012). Aside from this, it is important to provide natural enemies with a diversity of plants that bloom at overlapping times so there will be continuous food sources and overwintering sites for these arthropods (Patrício-Roberto and Campos 2014).

It is therefore essential to determine the potential to improve public perception of arthropods and their benefits. It is also necessary to determine which underlying factors contribute to the public's preconceived notions and negativistic attitudes toward arthropods. A better understanding of insect-related public perceptions and contributing negativistic attitudes will aid in implementation of proper education, teaching the general public through educational workshops, brochures, and online resources about the arthropod-mediated ecosystem services these organisms provide and proper management practices to ensure long-term conservation of arthropods (Patrício-Roberto and Campos 2014).

Materials and Methods

Public Perception Study. Arthropod specimens consisting of the carpenter bee [*Xylocopa* sp. (Latreille)] and honey bee [*Apis mellifera* (Linnaeus)] (F: Apidae), paper wasp [*Polistes* sp. (Latreille)] (F: Vespidae), lady beetle [*Hippodamia convergens* (Guérin-Méneville)] (F: Coccinellidae), Sleepy Orange Sulphur [*Eurema nicippe* (Cramer)] (F: Pieridae), Eastern

Swallowtail (F: Papilionidae) [*Papilio glaucus* (Linnaeus)] or Gulf Fritillary (F: Nymphalidae) [*Agraulis vanilla* (Boisduval & Le Conte)], stink bug [*Euthyrhynchus* sp. (Linnaeus)] (F: Pentatomidae), assassin bug (F: Reduviidae) [*Arilus cristatus* (Linnaeus)], ground beetle [*Calosoma* sp. (Weber)] (F: Carabidae), and an arachnid, e.g. wolf spider [*Hogna* sp. (Simon)] (F: Lycosidae) were collected, pinned, and placed in a display box with labels 1-10 (Figure 2.1.). Seventy-five survey respondents were asked to place pinned specimens in order of most (1) to least (10) appealing and rate each arthropod as "good" or "bad". Surveying occurred at various educational workshops and events from June 2013 to March 2014 until appropriate sample size was collected.

Survey participants consisted of Young Scholar (pre-collegiate program) students, Master Gardeners, County Extension Agents, and senior adults of First Baptist of Orchard Hill (Figure 2.2.). Demographics including age, gender, and amount of Entomology education were also recorded for each survey respondent. Respondents reported whether over or under age 20 and their gender. Likewise, no Entomology education, previous Entomology workshops or classes, or formal Entomology education through college was noted for each respondent. Once ranking was complete, a quick informative fact was given about the benefits of the arthropod ranked least appealing. The respondent was asked whether their attitude changed toward this "bug" and their response was recorded.

Statistical analysis. Demographic and arthropod placement and rank data was subjected to analysis of variance (ANOVA) with demographic data analyzed using the general linear model (GLM) procedure and arthropod placement and rank data subjected to the Univariate procedure. Means for level of entomology education, age, and gender were separated with Fisher protected least significant difference (LSD) test (SAS Institute 2010). The main effects of the variables were examined but interactions were not included in the model.

Results

Frequency of arthropod placement - Most appealing (1) to least appealing (10) insects. Of the ten common garden arthropods that were surveyed from most appealing (1) to least appealing (10), the Gulf Fritillary or Eastern Swallowtail butterflies were most often ranked in the first position, with 37 of the 75 survey respondents ranking the insect as first (1) (most appealing). The sulphur butterfly followed, with 31 survey participants placing this arthropod second (2) (Table 2.1.) Another popular insect that was most frequently ranked appealing was the lady beetle with 22 individuals positioning the insect as third (3) and 20 placing the insect as fourth (4). Likewise, the carpenter bee and honeybee varied in terms of placement but were both primary placed in fourth position (4). Throughout the study, 15 participants ranked the ground beetle as fifth (5) (Table 2.1.). No arthropod specimens were most frequently ranked in the sixth (6) or seventh (7) position. However, the stink bug was recurrently positioned as eighth (8) (Table 2.1) and the assassin bug and paper wasp were both primarily placed in the ninth (9) position by survey respondents. The least appealing arthropod was the arachnid, e.g. wolf spider with 21 individuals ranking the spider as tenth (10) (Table 2.1.)

Effects of Demographics on Arthropod Placement. Demographics of gender, age and amount of entomology education were collected for each of the seventy-five survey respondents and it was concluded that gender was only marginally significant (P = 0.0538) for the ground beetle ($F_{1,62}$ = 3.86). Males most often ranked the ground beetle as more appealing than female respondents (Table 2.1.). Likewise, the ground beetle was also very highly significant (P =

0.001) for age ($F_{1,62}$ = 11.91). Participants under the age of 20 found the ground beetle more appealing. Age was also significant (*P* = 0.0549) for the sulphur butterfly with individuals over the age of 20 ranking this arthropod as more appealing ($F_{1,62}$ = 3.83) (Table 2.1.)

Level of entomology education experienced by survey respondents was another important demographic factor which had an impact on arthropod placement. Education was highly significant (*P* = 0.0047) for the honeybee. Individuals with formal entomology education through college considered this pollinator more appealing ($F_{2,63}$ = 5.83) (Table 2.1.). Likewise, individuals with formal entomology education also found the Lady beetle to be more attractive ($F_{2,62}$ = 4.37, *P* = 0.0168). Level of entomology education was very highly significant (*P* = 0.0004) for the sulphur butterfly. Participants with no entomology education ranked the sulphur butterfly higher than those who had some entomology workshops or formal entomology education ($F_{2,62}$ = 9.02) (Table 2.1.) Level of entomology education was significant (*P* = 0.0160) for the stink bug, with individuals with no entomology education considering the insect more attractive, while respondents with formal education regarded the insect as less appealing. ($F_{2,63}$ = 4.42) (Table 2.1.).

Ranking of Arthropods as "Good", "Bad", or "Both". Upon asking the 75 survey respondents if an arthropod was "good or bad", a majority of the "bugs" were thought to be "good". In fact, 43 survey participants ranked the carpenter bee as a "good" insect and 60 individuals stated the honeybee was "good". (Table 2.2.) Likewise, the lady beetle was noted as a "good 'bug'" by 66 survey respondents. Both the sulphur butterfly and Gulf Fritillary and Eastern Swallowtail were more frequently labeled as "good" arthropods rather than "bad". Likewise the majority of individuals noted the arachnid, e.g. wolf spider, was a "good" arthropod. Forty-five respondents considered the ground beetle as a "good 'bug" (Table 2.2.) The stink bug, assassin bug, and paper wasp were most frequently considered as "bad" insects by the general public. Forty-nine people considered the stink bug as "bad'". Nonetheless, the assassin bug was considered a "bad" arthropod by 41 respondents while the paper wasp was noted as a "bad" insect by 45 individuals (Table 2.2.).

Effects of Demographics on Arthropod Ranking. There were certain demographics that influenced respondent's ratings of specific arthropods as "good", "bad", or "both". Significance among age (P = 0.0404) was determined for only one arthropod, the Wolf spider (Table 2.2). Survey participants under the age of 20 found the spider more appealing than those over the age of 20 ($F_{1,69} = 4.37$). Age did not significantly influence any other arthropods' ratings as "good", "bad", or "both good and bad". Likewise, gender also had no significance among these ratings. However, education was significant (P = 0.0269) for the assassin bug (Table 2.2.). Those individuals having formal entomology education considered the assassin bug as most appealing and were more likely to say it was a "good 'bug'" ($F_{2,69} = 3.81$). This was followed by those who had few entomology classes or workshops and those with no entomology education. Level of entomology education did not significantly affect any other arthropod rankings (Table 2.2.). After an informative fact was given about the benefits of the insect ranked least appealing by each respondent, sixty percent of these individuals were willing to change their attitudes towards the arthropod ranked least appealing.

Discussion

After assessing the frequency of insect placement by the 75 survey participants, the Gulf Fritillary or Eastern Swallowtail was most often placed as most appealing (1). The sulphur butterfly followed and was most frequently placed in the second position (2). Age and level of entomology education both affected ranking of the sulphur butterfly. Those over 20 found the sulphur butterfly more appealing. In previous research, Bjerke and Østdahl (2004) determined age and level of education plays a role in the perception of butterflies. Our study supports these findings as individuals with no education preferred the sulphur butterfly compared with those which had formal entomology education. This is most likely due to the diversity of entomology education among the survey participants. County Extension agents were a majority of the respondents with higher education and we believe these individuals had in mind the sulphur larvae which feeds on plants of the pea family (Fabaceae) rather than the adult form which was in the display box. Likewise when asked whether each of these butterflies were "good", "bad", or "both", the majority of respondents said the sulphur and the Gulf Fritillary or Eastern Swallowtail was a "good 'bug'". Our findings supported with published data that butterflies are highly perceived when compared to other insects and arthropods (Stanford Environmental Law Society 2001).

Likewise, the Lady beetle was most frequently ranked in third position and considered a "good" arthropod (Table 2.1. and 2.2.). This may be due to the insect's features and the familiarity of this insect by the general public. Kellert (1993) indicates that a large majority of the general public dislike ants, bugs, beetles, ticks, cockroaches, and crustaceans due to an aversion of these insects in their home. So it is remarkable, that this arthropod was ranked third. Education also played a role in the ranking of the ten common garden arthropods. Kellert's research (1993) suggests those that had more education perceived invertebrates higher than those with none or limited education. Nonetheless, the honeybee and carpenter bee were most frequently placed fourth (4) (Table 2.1.) When asked if these arthropods were "good", "bad", or "both", a large number of participants considered the honey bee and carpenter bee as "good" (Table 2.2.) While these pollinators are environmentally and agriculturally important, some respondents may dislike or fear these stinging insects. Nonetheless, carpenter bees can cause wood damage to public and private properties (Bambara and Waldvogel 2009).

Entomology education was significant for placement of the honeybee. Bjerke and Østdahl (2004) reported a higher preference for 17 out of 24 wildlife species groups including bees for participants that had higher levels of education. The ground beetle was most often placed fifth (5) and when asked whether "good", "bad", or "both" was said to be a "good" arthropod. Possible reasons for this placement could be due to the aesthetics. The ground beetle, *Calosoma* spp. (Weber), used in the display boxes was bright metallic green in color. Age and gender were also significant for ground beetle ranking. Survey respondents under the age of 20 found the beetle more appealing. Also, males found this arthropod more attractive (Table 2.1.) Recent studies indicate preferences for beetles are higher in men than women (Schlegel et al. 2010). Kellert (1993) determined elderly individuals express more fear and less ethical concern for invertebrates when compared with younger age groups.

The stink bug was most often placed in the sixth position and ranked as a "bad" arthropod. Possible causes of negative perception could be due to aesthetics and negativistic attitudes stemming from previous encounters with these insects such as aversion to stink bugs in the home or the foul odor they produce. Also, improper teaching and identification of stink bug pests vs. predatory stink bugs may have contributed to ranking and perception (Illinois Natural History Survey 2014). Level of entomology education was also significant with individuals having no entomology education perceiving the stink bug as more attractive. This is most likely due to the diversity of entomology education among the survey participants. Most of the higher educated survey respondents were County Extension agents that encounter plant-feeding stink bug pests on a daily basis and observe pest damage to agricultural crops. Proper education and identification of predatory vs. plant-feeding stink bugs can be implemented in order to potentially change negativistic attitudes toward this insect.

The assassin bug and paper wasp were most frequently placed ninth (9). Possible reasons associated with placement of the assassin bug may be due to aesthetics and unfamiliarity of this insect. Ranking of the paper wasp may be contributed to aesthetics or fear. Many *Polistes* spp. have bright yellow and orange warning colors with large stingers. Paper wasps also construct nests on the side of buildings and under over-hangings making them a nuisance (Cranshaw 2014). Kellert (1993) also stated some insects may be less preferred because of their ability to sting. When asked whether "good", "bad", or "both", the assassin bug and paper wasp were most frequently considered "bad". For the assassin bug, education also influenced arthropod perception with those having formal entomology education labeling the insect as "good".

The arachnid, e.g. Wolf spider (F: Lycosidae) was most frequently considered least appealing (10). However, when asked whether the arthropod was "good", "bad", or "both", a majority of respondents said it was "good". Fear, disgust, and aesthetics could all be reasons for the spider being considered least appealing. Our finding support previous research of the general public having an aversion, dislike, or fear towards most invertebrates but particularly spiders (Kellert 1993). However, in contrast with Kellert, we found that participants under age 20 found the arachnid more appealing compared to older individuals.

Sixty percent of the respondents changed their mind after learning about the ecological importance of the insect ranked least appealing. This suggests promoting these “bugs” can potentially change negativistic attitudes towards them. In summary, these findings offer further understanding of public awareness and attitudes toward insects, including pests and beneficial insects. Our study provides insight on how to properly educate the general public regarding common garden arthropods and also which of these "bugs” can be targeted through educational, extension, and outreach programs.

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Table 2.1. Survey respondent frequency insect ranks for listed arthropods and *P*-values and *F*-values for demographics: gender, age, and education associated with each insect ranks

Insect Name	Frequency of Insect Placement by Survey Respondents										Degrees of Freedom			P-value			F-value		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Gender	Age	Edu.	Gender	Age	Edu.	Gender	Age	Edu.
Carpenter Bee	4	1	9	**14**	12	9	6	2	6	12	1, 62	1, 62	2, 62	0.6537	0.6282	0.5285	0.20	0.24	0.64
Honey Bee	3	4	7	**17**	8	13	7	12	4	0	1, 63	1, 63	2, 63	0.5904	0.8744	0.0047**	0.29	0.03	5.83
Lady Beetle	8	6	**22**	20	6	5	1	2	2	3	1, 62	1, 62	2, 62	0.1213	0.4367	0.0168*	2.47	0.61	4.37
Sulphur Butterfly	15	**31**	10	5	6	1	2	2	2	1	1, 62	1, 62	2, 62	0.9889	0.0549*	0.0004***	0.00	3.83	9.02
Gulf Fritillary/Eastern Swallowtail	**37**	20	11	2	0	1	2	1	0	1	1, 64	1, 64	2, 64	0.7519	0.2431	0.1399	0.10	1.39	2.03
Stink Bug	1	0	1	6	8	3	15	**16**	11	14	1, 63	1, 63	2, 63	0.8940	0.7151	0.0160*	0.02	0.13	4.42
Wolf Spider	1	0	2	4	4	9	11	17	6	**21**	1, 63	1, 63	2, 63	0.4541	0.2960	0.6482	0.57	1.11	0.44
Assassin Bug	2	4	0	2	9	11	13	9	**14**	11	1, 63	1, 63	2, 63	0.0624	0.5098	0.7537	3.60	0.44	0.28
Paper Wasp	0	1	1	0	6	9	12	10	**27**	9	1, 64	1, 64	2, 64	0.4916	0.4513	0.1330	0.48	0.57	2.08
Ground Beetle	4	8	12	6	**15**	14	5	5	3	3	1, 62	1, 62	2, 62	0.0538*	0.0010***	0.5677	3.86	11.91	0.57

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

Table 2.2. Survey respondent frequency for perceptions of listed arthropods as good, bad, or both and *P*-values and *F*-values for demographics: gender, age, and education associated with each arthropod perception.

Insect perception frequency as good, bad, or both				**Degrees of Freedom**			**P-value**			**F-value**		
Insect Name	Good	Bad	Both Good and Bad	Gender	Age	Edu.	Gender	Age	Edu.	Gender	Age	Edu.
Carpenter Bee	**43**	31	1	1,69	1,69	2,69	0.8943	0.4289	0.1142	0.02	0.63	2.24
Honey Bee	**60**	15	0	1,69	1,69	2,69	0.4700	0.1932	0.1218	0.53	1.73	2.17
Lady Beetle	**66**	6	3	1,69	1,69	2,69	0.2722	0.7104	0.2342	1.23	0.14	1.48
Sulphur Butterfly	**62**	10	3	1,69	1,69	2,69	0.1331	0.5418	0.8337	2.31	0.38	0.18
Gulf Fritillary/Eastern Swallowtail	**64**	8	3	1,69	1,69	2,69	0.2427	0.5048	0.2830	1.39	0.45	1.29
Stink Bug	25	**49**	1	1,69	1,69	2,69	0.8785	0.9512	0.3847	0.02	0.00	0.94
Wolf Spider	**38**	35	2	1,69	1,69	2,69	0.7444	0.0404*	0.1273	0.11	4.37	2.12
Assassin Bug	32	**41**	2	1,69	1,69	2,69	0.3063	0.2121	0.0269*	1.06	1.59	3.81
Paper Wasp	24	**45**	1	1,69	1,69	2,69	0.7984	0.8875	0.2560	0.07	0.02	1.39
Ground Beetle	**45**	23	7	1,69	1,69	2,69	0.0893	0.0792	0.7292	2.97	3.18	0.32

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

Figure 2.1. Display box filled with labels 1-10 and pinned arthropod specimens: carpenter bee and honey bee (F: Apidae), paper wasp (F: Vespidae), lady beetle (F:Coccinellidae), Sleepy Orange Sulphur (F: Pieridae), Eastern Swallowtail (F:Papilionidae) or Gulf Fritillary (F:Nymphalidae), stink bug (F: Pentatomidae), assassin bug (F: Reduviidae), ground beetle (F: Carabidae), and an arachnid, e.g. wolf spider (F: Lycosidae)

Figure 2.2. County Extension agent participants (top photo) and senior adults of First Baptist of Orchard Hill (bottom photo) taking part in the insect perception survey.

CHAPTER 3

ASSESSMENT OF INSECTICIDES FOR THEIR EFFECT ON COMMON BUCKEYE BUTTERFLY (*JUNONIA COENIA)* AND SUPPRESSION OF LANTANA LACE BUG (*TELEONEMIA SCRUPULOSA*)

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ABSTRACT Lantana lace bug, *Teleonemia scrupulosa* (Stål), is a primary insect pest of lantana and verbena (Verbenaceae), popular flowering species in commercial and residential landscapes in the southern United States. In two greenhouse trials, six commercially available insecticides: imidacloprid (Merit® 75 WP), dinotefuran (Safari® 20 SG), insecticidal soap (M-Pede®), horticultural oil (Ultra-Pure™), neem oil (Garden Safe™), and chlorantraniliprole (Acelypryn™) were placed on Brazilian verbena [*Verbena bonariensis* (Linnaeus)] and evaluated for their effects on the Common buckeye butterfly [*Junonia coenia* (Hübner)] and suppression of the lantana lace bug (*Teleonemia scrupulosa* Stål). In both trials, butterfly mortality remained comparable to the control for dinotefuran (Safari® 20 SG) with 90-100 percent *J. coenia* mortality when exposed to Acelypryn™. The results from these trials will be useful for informing recommendations on control of lantana lace bug and conservation of pollinating lepidopterans.

KEY WORDS Commercially available insecticides, *Teleonemia scrupulosa*, *Junonia coenia*, *Verbena bonariensis,*

Many cultivars of lantana and verbena (Verbenaceae) are used as annuals or herbaceous perennials in containers, raised beds, and foundation shrubs in southeastern urban landscapes (Reinert and Davis 2006). Most of the cultivated species of lantana are native to tropical North and South America, while other species are native to warmer regions of the Old World (Reinert and Davis 2006). Lantana (USDA hardiness zone 7-10) are valued in the landscape industry for their floriferous, showy color, tolerance of drought, heat, and salt, aromatic florets and foliage, and attractiveness to butterflies and pollinating insects. Likewise, the herbaceous perennial, Brazilian verbena (*Verbena bonariensis* L.) (USDA hardiness zone 7-11) ranging in height from four to five feet, exhibits clusters of lavender umbels that bloom from late spring and into fall (Russ 2014). The cyme growth habit, self-seeding ability, and abundant nectar supply, all render this plant a valuable addition to any landscape (Russ 2014). However, the lantana lace bug (*Teleonemia scrupulosa*) poses a serious threat to the health of many Verbenaceae species in southeastern gardens and can often reduce or stop blooming (Reinert et al. 2006).

Lantana lace bug (*Teleonemia scrupulosa* Stål) is native to the tropical American regions and was originally described in 1873 by Carlos Stal after collecting specimens in Rio Janeiro, Brazil (Drake and Frick 1939). Since then the species was recorded in Brazil, Peru, British and French Guiana, Colombia, Venezuela, Central America, West Indies, Mexico and the southern United States (primarily Georgia, Florida, and Texas). *T. scrupulosa*' distribution in the Western Hemisphere is primarily linked with its verbenaceous host-plant genus Lantana (Drake and Frick 1939). All plant food records of *T. scrupulosa* are from Verbenaceae species, except two series of specimens from Texas. One series of lantana lace bug adults and nymphs were collected from an undetermined species of the mint family (Lamiaceae) in Houston Texas, and the other series was found on Poppy Mallow (*Callirhoe involucrate*). However, of those series collected, the insects were not able to breed or survive on the mint family (Labiatae) and Poppy Mallow (*Callirhoe involucrate*) (Drake and Frick 1939). Lantana has been reported as a weed in 47 countries, competing against fourteen crops and infesting millions of hectares (Reinert and Davis 2006). Therefore, *T. scrupulosa* has been used as a biological control agent in previous research.

In ornamental plantings in the southern United States, lantana lace bug is a pest of Verbenaceae species. The insect's behavior has been studied in Fiji, India, and Australia reporting the development of the nymphs on the underside of the leaves (Reinert and Davis 2006). The first signs of feeding damage by *T. scrupulosa* appear as yellowing leaves, followed by a silver-white bronzing, and eventually the leaves become brown (Townsend et al. 1999). Other signs of *T. scrupulosa* damage include insect frass or immature "skins" found on the underside of leaves and feeding damage on immature flower buds resulting in reduction or prevention of blooming (Johnson and Lyon 1991). Therefore, it is important to assess standard and alternative insecticides that can be used to suppress *T. scrupulosa* without harming native pollinating insects and butterflies that may visit Verbenaceae species for food and nectar resources (Watanabe 2014).

Systemic insecticides such as neonicotinoids: dinotefuran (Safari) and imidacloprid (Bayer Advanced Tree & Shrub Insect Control, Merit) and the organophosphate acephate (Lilly Miller Ready-to-Use Systemic, Orthene) have proven effective for the control and suppression of lace bugs (Dreistadt 2014) yet are not suitable when attempting to attract pollinators, butterflies, and may kill beneficial insects. Likewise, non-residual insecticides such as insecticidal soaps (Safer), narrow-range oil (Monterey Horticultural Oil, Volck), neem oil (Green Light, Garden SAFE) may also be used to control *T. scrupulosa* during summer and early fall when lantana is in full bloom (Dreistadt 2014). Non-residual insecticides provide short-term pest control but are less toxic to hard-bodied beneficial pollinating insects, and butterflies (Hall and Richardson 2012).

Studies from the Department of Zoology in Bhadohi, India, determined that environmental-friendly neem-based insecticides (NBI), when applied topically to larvae of *Papilio demoleus* L. caused reduction to length of ovariole, number of oocytes per ovariole, and decreased body weight. Negative changes in wing shape and pigmentation were also recorded (Suyog et al. 2011). Nonetheless, successful pest control can be attained through the use of residual insecticides. Studies confirm successful suppression of the crape myrtle (*Lagerstroemia* L.) aphid [*Tinocallis kahawaluokalani* (Kirkaldy)] (Layton and Gu 2009a) and sweet potato (*Ipomoea batatas* L.) whitefly [*Bemisia tabaci* (Gennadius)] (Layton and Gu 2009b) through the use of non-residual insecticidal soaps.

This study was undertaken to evaluate the potential of alternatives and standard insecticides to: 1) control *T. scrupulosa* pest in Verbenaceae plant species, and 2) have the least negative impact on desirable butterfly species.

Materials and Methods

Rearing of Adult *T. scrupulosa*. Adult *T. scrupulosa* were collected from natural populations near Griffin, GA and maintained in (60.9 cm- x 60.9 cm x 60.9 cm) BugDorm-2120 insect rearing cages (Megaview Science Co. Taichung, Taiwan BD2120 in a glass-covered greenhouse on several lantana cultivars under conditions of 21.1 to 22.2°C.

Experiment Set-Up. Insecticide trials took place at the University of Georgia Griffin Campus, Griffin, GA (Spalding Co.) (USDA hardiness zone: 8a) from March 24 to April 13, 2014 and was repeated from April 17 to May 7, 2014. Thirty-five (60.9 cm- x 60.9 cm x 60.9

cm) BugDorm-2120 insect rearing cages (Megaview Science Co. Taichung, Taiwan BD2120) were set up in a glass-covered greenhouse in a randomized complete block design (RCB) with five replications. Each cage was placed on steel-mesh benches (152.4 cm x 579.1 cm) and spaced 21.6 centimeters apart for air ventilation (greenhouse day temperature set at 22.2°C and night temperature set at 21.1°C). A single potted Brazilian verbena (*V. bonariensis*) (1 gallon, Goodness Grows Inc., Lexington, GA) was placed under each cage to serve as a host plant for *T. scrupulosa* (Figure 3.3). In the cage, potted verbena (height: 90-120 cm, flower head size: 1.27-2.54 cm) were placed in sand-filled Styrofoam plates used to collect water for plants. This prevented drowning of *T. scrupulosa*, and provided water and salt for emerging *J. coenia*.

After sex had been microscopically determined, five male and five female *T. scrupulosa* adults were added to the foliage of *V. bonariensis* using a fine-bristled paintbrush (Figure 3.4.). Five days following introduction of *T. scrupulosa,* all verbena blooms were removed and each plant was sprayed with appropriate insecticidal treatment inside the cage. Insecticidal drift was prevented during application of treatments by using a foam board shield (Figure 3.5.). Treatments consisted of commercially available insecticides applied at median label lace bug rates (Table 3.1): imidacloprid (Merit® 75 WP), dinotefuran (Safari® 20 SG), insecticidal soap (M-Pede®), horticultural oil (Ultra-Pure™), neem oil (Garden Safe™), chlorantraniliprole (Acelypryn™), and a control (no spraying occurred). The spray materials were applied to the potted *V. bonariensis* in the BugDorm cages using a meter jet gun with a CO_2 sprayer and chlorantraniliprole (Acelypryn™) was applied as a soil application using a 100 mL graduated cylinder. Seven days after chemical applications were applied, two common buckeye butterfly (*Junonia coenia* Hübner) chrysalises were inserted in to each cage. The chrysalises were placed in two separate petri dishes at opposite ends of cage and left to emerge (Figure 3.6.).

Data Collection: Insect-Related Data. Once chrysalises were placed in each cage, visual observations occurred daily over a five-minute period for butterfly emergence, butterfly health, location of butterflies, length of butterfly visitation during 2-min period, and mortality. Emergence was recorded as 0=no emergence, 1=one insect emerged, and 2=both insects emerged. Butterfly health was denoted as 0=dead or no emergence, 1=good health, 2=poor health. Mortality was also recorded as 0=no mortality, 1=one insect dead, and 2=both insects dead.

Data Collection: Plant-Related Data. Number of *V. bonariensis* inflorescences for each day of the trials was recorded *T. scrupulosa* damage ratings on foliage and immature and mature florets of *V. bonariensis* were also recorded using damage scale (Fig. 3.7.) *T. scrupulosa* damage ratings recorded included yellowing leaves, followed by a silver-white bronzing, insect frass or immature "skins" found on the underside of leaves and feeding damage on immature and unopened flower buds.

Treatment statistical analysis. Treatment data for *J. coenia* mortality were analyzed separately for each experimental run. Through initial analysis, it was determined that two dates must be chosen for each trial in order to provide a complete understanding of which insecticidal treatment provided adequate suppression of *T. scrupulosa* yet caused minimal effects on butterfly health. During the first date chosen for analysis for trial 1 (day 3) and trial 2 (day 4), there was complete butterfly emergence, no sign of mortality, and superior health for all butterflies. For the second date chosen for trial 1 (day 7) and trial 2 (day 9), complete emergence, 60-70% mortality, and variable butterfly health were noted. Treatment data for trial 1 (day 3 and day 7) and trial 2 (day 4 and day 9) were subjected to analysis of variance (ANOVA) using the generalized linear mixed model (GLIMMIX) procedure. Insecticide treatments were treated as a fixed effect and replicates were treated as a random effect. The counts were modeled using a binomial distribution. Means for treatment data in both experimental runs were separated with Fisher least significant difference (LSD) test (SAS Institute 2010).

Correlation statistical analysis. The Correlation procedure was preformed to obtain Pearson product-moment correlation coefficient for the relationship of *V. bonariensis* flower number and percentage of *T. scrupulosa* damage as well as *J. coenia* mortality and lace bug target insecticide treatment exposure.

Results

Systemic Vs. Non-Residual insecticides. The systemic insecticides, dinotefuran (Safari® 20 SG) and imidacloprid (Merit® 75 WP), and chlorantraniliprole (Acelypryn™) were also applied at median label rates for *T. scrupulosa* control (Table 3.1) After moderate exposure to chlorantraniliprole, there was 90% *J. coenia* mortality that occurred on days 5-7 in trial 1 (Fig. 3.1.) and 100% *J. coenia* mortality that occurred on days 7-9 in trial 2 (Fig. 3.2.) For this reason, chlorantraniliprole (Acelypryn™) was omitted from the Generalized Linear Mixed Model (GLIMMIX) procedure and further analysis in both trials because all butterflies exposed to this treatment were killed rapidly after emergence and moderate exposure to the insecticide. For trial 1, mortality was not significant (P = 0.7086) among remaining insecticidal treatments ($F_{6,24}$ = 0.59). For trial 2, butterfly mortality was marginally significant (P = 0.0638) among remaining insecticidal treatments ($F_{6,24}$ = 2.44). In trial 1, systematic insecticide treatments dinotefuran (Safari® 20 SG) and imidacloprid (Merit® 75 WP) did not differ from the control in terms of butterfly mortality (Table 3.2). Similiarly in trial 2, dinotefuran (Safari® 20 SG) remained comparable to the control while imidacloprid (Merit® 75 WP) slightly differed from the control ($F_{6,24}$ = 2.44) (Table 3.2).

The three non-residual insecticides: potassium salts of derived fatty acids (M-Pede® Insecticidal Soap), petroleum oil (Ultra-Pure™ Horticultural Oil), and neem oil (Garden Safe™ Neem Oil) were applied at lace bug targeted median label rates (Table 3.1). Non-residual insecticides potassium salts of derived fatty acids, petroleum oil, and neem oil varied from the control in terms of butterfly mortality in trial 1 and 2 (Table 3.2). In trial 1, petroleum oil and neem oil had highest means of treatment mortality, while in trial 2, petroleum oil had the largest treatment mortality mean.

Correlation Among Variables. Correlations were used to determine the relationship between butterfly mortality and lace bug targeted insecticide treatment exposure as well as the relationship between *V. bonariensis* flower number and percentage of *T. scrupulosa* damage. Moreover, this data was included because it demonstrates butterfly mortality and *T. scrupulosa* damage over 21 days whereas previous analyses focused primarily on day 3 and day 7 (trial 1) and day 4 and day 9 (trial 2). Analysis of correlation among mortality of *J. coenia* and lace bug targeted insecticide treatments suggested positive correlation in trial 1. Correlation coefficients among mortality of *J. coenia* and lace bug targeted insecticide treatments remained positive for day 1-5 (r = 0.07358, P = 0.3332), day 6-10 (r = 0.14975, P = 0.0486), day 11-15 (r = 0.11759, P = 0.0210), and day 16-21 (r = 0.02915, P = 0.6745) (Table 3.3). During trial 2, positive correlation among butterfly mortality and lace bug targeted insecticide treatments was found during day 1-5 (r = 0.05973, P = 0.5826) and day 11-15 (r = 0.11880, P = 0.2731) and negative correlation occurred during day 6-10 (r = -0.08993, P = 0.4075) and day 16-21 (r = -0.07398, P = 0.4532). (Table 3.3).

Correlation among flower number for *V. bonariensis* and percentage of *T. scrupulosa* damage was also observed in both experimental runs (Table 3.4). During trial 1, positive correlation among *V. bonariensis* flower count and percentage of *T. scrupulosa* damage was seen during day 1-5 (r = 0.20959, P = 0.0054), day 6-10 (r = 0.19972, P = 0.0082), day 11-15 (r = 0.24967, P = 0.0008), and day 16-21 (r = 0.28177, P = <0.0001) (Table 3.4). In trial 2, correlation among flower number and insecticidal treatments was also seen in with negative correlation during day 6-10 (r = -0.02637, P = 0.8084) and day 16-21 (r = -0.00381, P = 0.9693) and positive correlation on day 1-5 (r = 0.06742, P = 0.5350) and day 11-15 (r = 0.00516, P = 0.9622) (Table 3.4).

Discussion

For both non-residual and systemic lace bug targeted-materials that were applied, no material proved to be considerably less toxic or detrimental to exposed *J. coenia* during trial 1 and trial 2. Imidacloprid (Merit® 75 WP) and dinotefuran (Safari® 20 SG) were found to have comparable butterfly mortality means with that of the control in which no chemical application occurred in trial 1. When applied as a foliar spray, the materials are absorbed in the foliage and are translocated to the foliar margins as well as penetrate the leaf tissues and form a reservoir of active ingredient within the leaf. These two materials act on the nicotinic acetylcholine receptors of sucking (aphids, lace bugs, scale, mealybugs) and chewing insects (beetles, weevils, borers, leafminers) (Texas A&M Extension 2014). Lepidoptera possess different modes of feeding not targeted by the two systemic insecticides, and this could explain the lower butterfly mortality (Krenn 2010).

Of the non-residual materials applied, M-Pede® insecticidal soap had lower mortality compared to the two other non-residual insecticides: petroleum Oil (Ultra-Pure™ Horticultural Oil) and neem oil (Garden Safe™ Neem Oil) in both experimental runs. Chlorantraniliprole (Acelypryn™) killed 90-100% of *J. coenia* by day 7 (trial 1) and day 9 (trial 2) in trials 1 and 2, .

This is likely due to its unique mode of action, binding to ryanodine receptors of insect muscles. Chlorantraniliprole has been used to effectively control armyworms, cutworms and sod webworms (Dupont Chemical Company 2009). Potassium salts of fatty acids (M-Pede® Insecticidal Soap) works on contact**,** targeting the protective coat of soft-bodied insects, causing dehydration to pests such as adelgids, aphids, caterpillars, earwigs, lace bugs, leafhoppers, and tent caterpillars (Ubl 2014). Due to its mode of action, *J. coenia* are likely less susceptible to M-Pede®**.** Petroleum oil and neem oil proved most toxic to *J. coenia* in both trial 1 and trial 2 with petroleum oil having a higher mortality in trial 2 (Table 3.2) This is likely due to the smothering mode of action by most horticultural oils causing insects to expire on contact (Ubl 2014). Nonetheless, neem oil does not necessary kill on contact but rather interferes with the normal life cycle of insects including feeding, molting, mating, and egg-laying (Pundt 2000). *J. coenia* were not exposed to the insecticidal treatments until seven days after applications occurred. Therefore, exposure to these alternative insecticides resulting in higher *J. coenia* mortality when compared to the control is likely contributed to volatile uptake of the materials rather than contact uptake by *J. coenia*.

With the exception of chlorantraniliprole, lace bug-targeted materials used were similar in their effects on *J. coenia* adults during three-week exposure. These data will be used to provide recommendations on the applied use of systemic and non-residual insecticides for *T. scrupulosa* control and limited effects on pollinating lepidopterans.

Correlation Among Variables. During trial 1, a significant positive correlation was found among mortality of *J. coenia* and exposure to lace bug-targeted insecticide materials during day day 6-10 and day 11-15. This is to be expected after results confirmed *J. coenia* mortality among insecticidal treatments. However, there was not a significant positive correlation for *J. coenia* mortality and lace bug-targeted insecticide exposure for day 1-5 and day 16-21 in trial 1. For trial 2, there was no significant correlation for day 1-5, day 6-10, day 11-15, and day 16-21 for *J. coenia* mortality and exposure to insecticide treatments.

Significant positive correlation was seen among V. *bonariensis* flower number and percentage *T. scrupulosa* damage during day 1-21 (Table 3.4.). Possible causes for the positive correlation during day 6-10 in this trial may be due to the increased number of *V. bonariensis* flowers causing additional feeding by *T. scrupulosa* during this period. Blooms were removed before insecticide applications were applied and flower number was highest in day 8. In previous literature, *T. scrupulosa* has been reported feeding on immature and unopened flower buds of lantana and verbena cultivars (Townsend et al. 1999). In trial 2, there was no significant correlation between experimental variables, V. *bonariensis* flower number and percentage *T. scrupulosa* damage during day 1-21.

Systemic insecticides have long been considered a major factor contributing to the overall declining pollinator health and abundance (Colin et al. 2004). In fact, systemic insecticides that move via sap through treated plants are strong agonists of an insect's nicotinic acetylcholine receptors. Moreover, many of these insecticides are used in the turf and ornamental industry for treatment of insect pests. Although effective on insect pests, chlorantraniliprole, the active ingredient of Acelypryn™, received reduced-risk status by the US Environmental Protection Agency (Held et al. 2012) due to its low hymenopteran toxicity. This insecticide is used in turf to treat root-feeding scarab grubs and weevil larvae, and has been reported to have low acute bee toxicity when applied to clover under field conditions (Cordova et al. 2006). Larson et al. (2013)

suggests this insecticide is a more bee-friendly option for insect control in lawns, gardens, and other settings. However, our findings indicate that mortality rate was extremely high for the *J. coenia* butterflies exposed to chlorantraniliprole and this product has been reported to work rapidly on lepidopteran pests (Larson et al. 2013). Therefore, it is important to consider all potential pollinators including hymenopterans, lepidopterans, and other beneficial insect species that may be affected by application of systemic insecticides such as chlorantraniliprole.

In summary, lace bug-targeted materials had similar effects on *J. coenia* adults with the exception of chlorantraniliprole (Acelypryn™). Neonicotinoid insecticides including imidacloprid (Merit® 75 WP) and dinotefuran (Safari® 20 SG) were comparable to the control yet have been reported to severely affect pollinating hymenopterans. Our findings conclude chlorantraniliprole (Acelypryn™) affect Lepidoptera but are not reported to harm Hymenoptera. Therefore, alternative insecticides (i.e. potassium salts of derived fatty acids, petroleum oil, and neem oil) should be used to control *T. scrupulosa* while limiting effects on pollinators and natural enemies.

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Table 3.1. List of chemicals with their trade name, active ingredients, formulation, and median label rates (per 100 gallons of water unless otherwise mentioned) for treatment of lace bug (F: Tingidae) species.

Trade Name	Active Ingredient	Median Label Rate
Control	–	–
Safari® 20 SG	Dinotefuran	6 oz.
Merit® 75 WP	Imidacloprid	1.67 oz.
M-Pede® Insecticidal Soap	Potassium salts of fatty acids	2 gal.
Ultra-Pure™ Horticultural Oil	Petroleum Oil	1.2 gal.
Garden Safe™ Neem Oil	Neem Oil	0.80 gal.
Acelypryn™	Chlorantraniliprole	0.125 oz. per plant per inch diameter DBH

Table 3.2. Means (±S.E.M.) of mortality of the Common Buckeye Butterfly (*J. coenia*) at observation dates with least exposure (day 3,4) and moderate exposure (day 7,9) to materials in Trial 1 (day 3,7) and Trial 2 (day 4,9) after exposure to lace bug-targeted materials at median label rates (Table 3.1)

Treatment	**Trial 1**	**Trial 2**
	Day 3 and Day 7	Day 4 and Day 9
Control	0.40±0.16a	0.10±0.09c
Safari® 20 SG	0.40±0.16a	0.10±0.09c
Merit® 75 WP	0.40±0.16a	0.20±0.13bc
M-Pede® Insecticidal Soap	0.30±0.15a	0.40±0.16abc
Ultra-Pure™ Horticultural Oil	0.60±0.16a	0.70±0.15a
Garden Safe™ Neem Oil	0.60±0.16a	0.60±0.16ab
Acelypryn™	100	90
P value	0.7086	0.0638
f	0.59	2.44
df	6, 24	6, 24

Acelypryn™ treatment was not included in analysis using Generalized Linear Mixed Model (GLIMMIX) procedure.

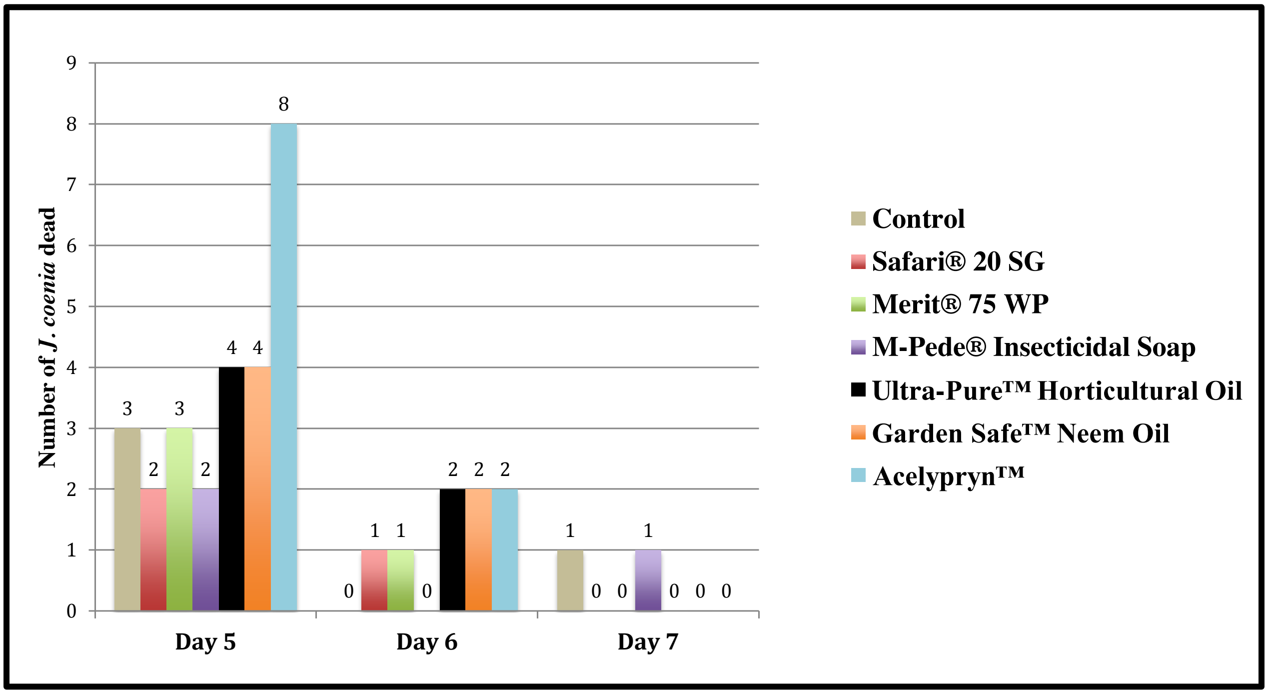

Figure 3.1. Number of dead *J. coenia* after exposure to six insecticides and control on day 5, day 6, and day 7 in trial 1.

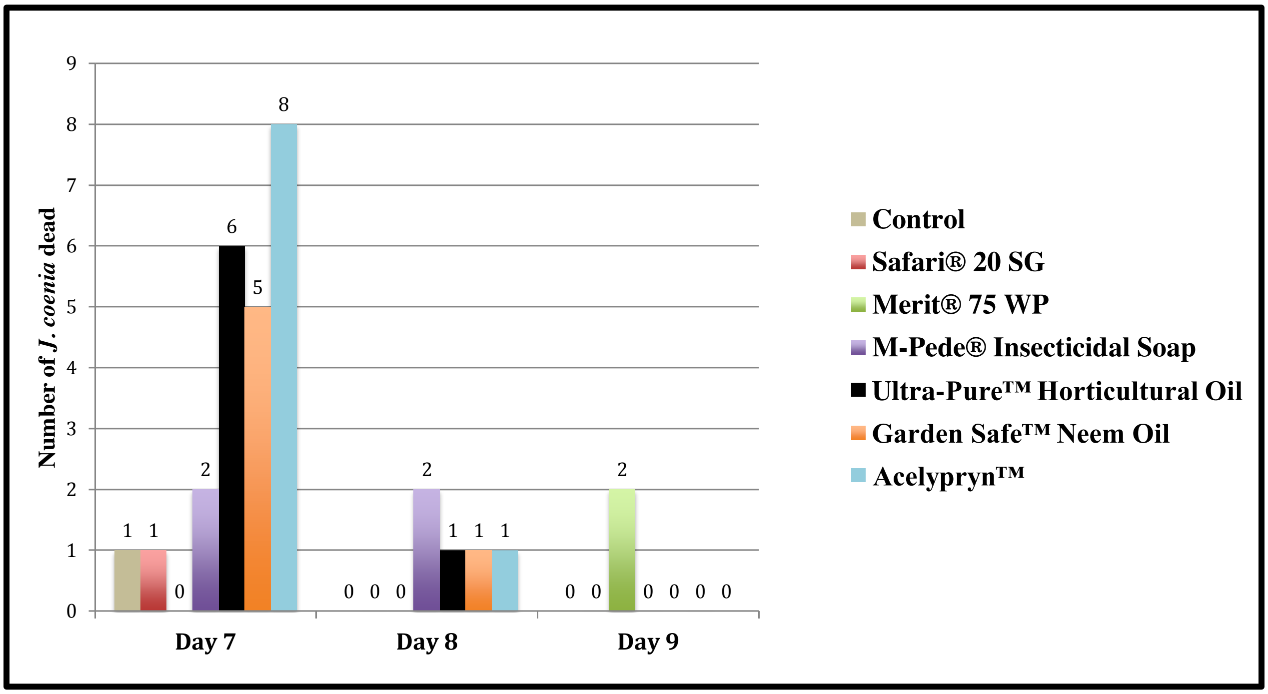

Figure 3.2. Number of dead *J. coenia* after exposure to six insecticides and control on day 7, day 8, and day 9 in trial 1.

Table 3.3. Correlation coefficients of *J. coenia* mortality and lace bug-targeted insecticidal treatments in two experimental runs over a twenty-one day period.

Observation dates (Day 1-21)	**Trial 1**		**Trial 2**	
	Pearson's Correlation Coefficient (*r*)	***P*-value**	**Pearson's Correlation Coefficient (*r*)**	***P*-value**
Day 1-5	0.07358	0.3332	0.05973	0.5826
Day 6-10	0.14975	0.0486	-0.08993	0.4075
Day 11-15	0.11759	0.0210	0.11880	0.2731
Day 16-21	0.02915	0.6745	-0.07398	0.4532

* indicates statistical significance at $P < 0.01$

Table 3.4. Correlation coefficients of *V. bonariensis* flower number and percentage of *T. scrupulosa* damage in each Trial (1,2) over a twenty-one day period

Observation dates (Day 1-21)	**Trial 1**		**Trial 2**	
	Pearson's Correlation Coefficient (*r*)	***P*-value**	**Pearson's Correlation Coefficient (*r*)**	***P*-value**
Day 1-5	0.20959	0.0054*	0.06742	0.5350
Day 6-10	0.19972	0.0082*	-0.02637	0.8084
Day 11-15	0.24967	0.0008*	0.00516	0.9622
Day 16-21	0.28177	<0.0001*	-0.00381	0.9693

* indicates statistical significance at $P < 0.01$

Figure 3.3. BugDorm-2120 insect rearing cages (Trial 1) filled with *V*. *bonariensis* testing insecticidal suppression of *T*. *scrupulosa* and toxic effects of *J*. *coenia*

Figure 3.4. Sexing of *T*. *scrupulosa* (top photo) and addition of *T*. *scrupulosa* onto *V*. *bonariensis* plants post- treatment (bottom photo)

Figure 3.5. Spraying of lace bug-targeted materials after addition of *T*. *scrupulosa* females and males to *V*. *bonariensis*

Figure 3.6. *J*. *coenia* larvae attached to rearing cage before emergence (top photo) and adult *J*. *coenia* resting on *V*. *bonariensis* after emergence (bottom photo)

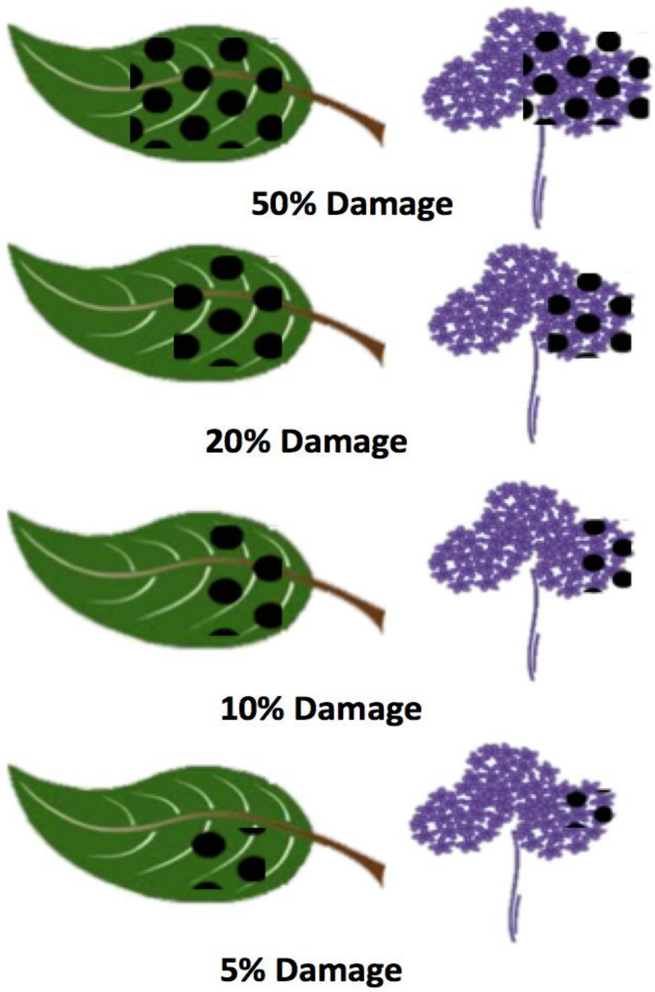

Figure 3.7. Schematic representation of percentage of *T. scrupulosa* damage on *V. bonariensis* leaves and florets rated in experimental runs.

CHAPTER 4

INFLUENCE OF PLANT PARAMETERS ON OCCURRENCE OF POLLINATOR, BENEFICIAL, AND BUTTERFLY POPULATIONS

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ABSTRACT Insects provide ecosystem services such as pollination and biological control. Additionally, flowering ornamental plant species have the potential to support beneficial insect communities such as pollinating bees, wasps, and predatory plant bugs. We conducted visual observations and sampled via pan traps, sweep nets, and sticky traps to assess the potential of flowering ornamentals to act as a conservation resource for pollinators and beneficial insects. Hoverflies (F: Syrphidae), small bees (*Lasioglossum (dialictus) imitatum* Smith *and Halictus ligatus* Say), skippers (F: Hesperiidae), predatory plant bugs (F: Miridae) and parasitic Hymenoptera were frequent visitors among flowering plants of the UGA Butterfly and Conservation Garden. Insect-attracting plant species, Anise Hyssop 'Black Adder' (*Agastache* (Pursh) Kuntze 'Black Adder') and Celosia (*Celosia spicata* L.) influenced potential pollinator and beneficial insect visitation. The results from these experiments will be useful for informing recommendations on the applied use of flowering ornamental plant species for pollinating and beneficial insect conservation purposes.

KEY WORDS beneficial arthropods, pollinating arthropods, conservation, flowering ornamental plants

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As decomposers, predators, and pollinators, insects play a vital role in the ecosystem and on human health. These decomposers help aerate the soil, turning more soil than earthworms and increasing soil rainwater retention and tillage (Pimentel 2002). Predatory insects help keep the natural system in balance and prevent explosive pest population growth from taking over essential natural resources. There are over 6,000 insect species that have been considered biological control agents and are being used to fight insect and weed pests (Pimentel 2002). Moreover, there are countless other insect species that act as pest population regulators but often go unnoticed. Insects are also a crucial part of food security in the United States, with 87 of the leading 115 food crops depending upon insect pollinators (U.S. Fish and Wildlife Service 2014). These plants cannot set fruit without the help of insects carrying pollen from flower to flower. Plants use a variety of characteristics such as color, shape, and odor to attract insects insuring that these flower visitors will not leave without being dusted with pollen. Certain flower types are adapted for attracting certain insect groups such as bees, butterflies, wasps, moths, beetles, and flies (Pimentel 2002). Pollinators and floral characteristics are linked directly to evolution with many plants depending on their mutualistic relationships with pollinating arthropods for survival. In turn, pollinators rely on flowering plants to acquire food including pollen and nectar (Kearns and Inouye 1997).

Research shows that pollinators contribute to 35% of the world's food production and 24 billion dollars in the United States economy (NRC National Research Council 2007). Likewise, native pollinators such as bumble bees, sweat bees, and leafcutter bees provide crop benefits which are valued at more than 9 billion dollars. Evidence suggests that pollinating insects of crops, native, and ornamental plants are declining worldwide

(NRC National Research Council 2007). The changes in land-use, loss and fragmentation of habitat, modern agricultural practices, and pesticide use pose great threats to these insect pollinators and natural enemies (Nicholls and Altieri 2013). Since 2006, it has been reported that western honey bee (*Apis mellifera* L.) colony loss rates have increased to an average of 30% each winter and this is said to be contributed from a variety of factors including loss of natural forage and inadequate diets, mite infestation and diseases, loss of genetic diversity, and exposure to certain pesticides (NRC National Research Council 2007). Other native pollinators, including bumble bees and Monarch butterflies (*Danaus plexippus* L.), have experienced population declines as well (NRC National Research Council 2007). The National Research Council reports the use of systemic pesticides used in production of agricultural products, including ornamental plants, as one of the factors contributing to declining pollinator health (NRC 2007).

Habitat management has been used to enhance biological control and pollinator visitation in agricultural systems by providing resources that include food such as pollen, alternative hosts, and shelter from adverse environmental conditions (Landis, Wratten and Gurr 2000). Proper plant selection to provide these floral resources can be incorporated into a managed garden system or plant communities (Landis, Wratten, and Gurr 2000).

In turn, by providing these essential floral resources to natural enemies and pollinating insects, increased biological control and pollination has been reported (Fiedler and Landis 2007). Research suggests a diverse butterfly population can be attained through the addition of annual, perennial, and woody shrub ornamental species to a landscape. In a study conducted by Fordham University and the American Museum of

Natural History, over a four-year period, 54 species of bees (13% of the New York State fauna) were collected in urban community gardens around New York State. It was noted that these gardens provide food resources through flowers as well as nesting areas that contribute to the survival and reproduction of bees (Matteson, Ascher, and Langellotto 2008). Likewise by attracting this diverse bee assemblage, pollination services are also provided. Similar results were found in community garden studies in California (Frankie et al. 2005) and Arizona (McIntyre and Hostetler 2001).

By monitoring pollinator and beneficial insect occurrence within habitat management sites, ornamental plant species can be evaluated for their arthropod attractiveness and the provision of arthropod-mediated ecosystem services (AMES) including pollination and biological control in southeastern landscapes (Kremen et al. 2007). In the studies herein, several methods were used to monitor pollinator and beneficial insects including: visual observations, sweep-net sampling, pan trapping, and sticky card trapping. Sweep-net sampling was used, as it is effective at collecting small, flying invertebrates that may not be collected in other sampling methods (Schmidt et al. 2008) and can be used to collect Lepidoptera (Doxon et al. 2011). The sweep-net sampling methods performed according to Schmidt et al. (2008) was used to effectively monitor insect occurrence.

Previous studies monitored pollinator and butterfly occurrence through pan trapping (Hudson 2013). Flower color and shape are highly important when attracting pollinating insects to a garden so by implementing different color and shape pan traps, pollinator occurrence can be surveyed (Westphal et al. 2008). Several studies report different types of insects that are attracted to particular colors (Brødsgaard 1989). The color yellow has successfully been used to capture Hymenoptera and flies; red is effective for some beetles; and white attracts flies and grass-dwelling insects (Vrdoljak and Samways 2012).

Sticky card trapping can survey minute insects that may not be collected in other trapping methods. Wallis and Shaw (2008) noted sticky traps are useful for monitoring the presence of beneficial insects and their numbers can reflect the densities of their host pests. In addition, sticky trap color can affect the attraction of diurnally-active insects (Vernon and Gillespie 1990) with studies suggesting yellow is the best sticky card color for trapping beneficial insects such Coleopteran predators and Hymenopteran parasitoids (Dowell and Cherry 1981).

The aims of this study were two-fold: 1) to provide detailed information on the attractiveness of a wide selection of ornamental floral resources to pollinators, natural enemies, and plant-feeding insects, and 2) to determine the effect of various plant attributes on insect visitations.

Materials and Methods

Growing Environment. The research was conducted at the UGA campus, Griffin, GA. The butterfly and conservation gardens were established in autumn 2012 (soil type: sandy clay, pH: 5.1, OM: 3.25%, %C: 0.16%, %N: 0.04%) containing 74-76 commercially available perennial, annual, and native plant species (Table 4.1. and Table 4.5). Annual plant species (Thyme After Thyme Inc., Athens, GA) were in 6-inch pots, herbaceous perennials in 1-gallon containers, and woody shrubs in 3-gallon containers. Irrigation (Hunter Industries Controller with MP Rotator heads on risers) was installed by members of Georgia Green Industry Association Irrigation Division and provides 2.54

cm of water weekly. Mini-nugget mulch (West Fraser Timber, Opelika, AL) was added in 2014 as bedding preparation. These plants were selected based on their attractiveness to pollinating and beneficial insects and their horticultural attributes and superior adaptability to the southeastern growing environment. There were 4 replicate plots within the garden, three were contiguous, while the fourth was located in close proximity. Within each replicated plot, each plant cultivar had three sub-samples (Figure 4.1). Insect activity, abundance, and diversity were evaluated using visual observations and sweep net, color pan, and sticky card sampling.

Visual Observations of Insect Visitation. Each of the four garden replicate plots was monitored using visual observations at 10:30 a.m.-11:30 a.m. and 2:30 p.m.-3:30 p.m. twice weekly from June 4-September 5 and once weekly from August 26 to November 4, 2013 (Figure 4.1). Each plant was observed for 2-3 seconds and observations recorded included: family and order of insects viewed and plant or location the insect was found. Data were collected in the field using an Apple iPad and a work notebook and later entered in digital form in an Excel spreadsheet. Visual observations, along with photography and insect trapping methods, were utilized for better identification of specific beneficial and pollinating insect species.

Color Pan Trapping. Red, yellow, blue, and violet plastic cups (width: 9.5 mm, height: 12 mm) and red, blue, and yellow plastic bowls (width: 14.5 mm, height: 8.5 mm) served as traps (Table 4.10). Pan traps were spread three-feet apart along the walking path in the center of the gardens and placed in a randomized complete block design (RCB) with four replications. Each shape and color trap was placed at ground level or on a 91.4 cm stand and filled with a soapy solution (10 mL of dishwashing detergent per/ 3.79 liters of water) to prevent insects from flying out. Sampling occurred over a three-date period during June 20-June 25, 2013. Insects were transferred to alcohol and returned to the laboratory.

In Summer 2014, only yellow bowls (width: 14.5 mm, height: 8.5 mm) located on the ground served as traps and were arranged at both ends of each of the four replicated gardens for a total of 8 replicates. Sampling intervals were 6-7 days from June 25-August 4, 2014. Bees collected in the Summer 2013 and 2014 samples were identified using appropriate keys and reference collections maintained in the museum at University of Georgia Griffin and Athens Campuses (Table 4.14 and Table 4.15).

Sweep-Net Sampling. Thirty-nine plant taxa were sampled with an aerial net (Bioquip® Products, diameter: 30.48 cm, handle length: 45.72 cm) over the leafy-flowering foliage of each plant five times. Sweep-net sampling occurred once a week from June 10-July 22, 2014. Sweep-net contents were placed into a plastic bag and stored in a freezer for preservation until sorting, mounting, and insect identification occurred.

Sticky Card Trapping. The sticky card trapping procedures performed according to Wallis and Shaw (2008) were used to monitor flying insect species such as hymenopteran parasitoids, coleopteran predators, and dipteran pollinators. This method of trapping was implemented in Summer 2014 to monitor minute, beneficial insects that may not have been recorded through visual observations, sweep-net sampling, or pan trapping. Yellow sticky trap cards (width: 7.62 cm, height: 12.7 cm) were placed on utility posts at heights of two-foot (60.9 cm) and four-foot (121.9 cm) in each of the four replicated gardens. All sticky trap cards were held in place on the utility post using two binder clips and each utility post containing the yellow sticky card traps were placed at opposite ends of each of the four replicated garden sections for a total of eight traps. Trap sample intervals occurred every seven days from June 3-August 5, 2014. Traps were examined under a stereo microscope.

Data Analysis. Data were subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure. For Summer and Fall 2013 visual observations, plant type and sampling date were analyzed as main effects. Pan trap type and sampling date were analyzed as main effects during Summer 2013 pan trapping and sampling date was analyzed as a main effect in Summer 2014 pan trapping. For 2014 sticky trap sampling, sticky trap height and sampling date were analyzed as main effects. Plant type and sampling date were examined as main effects during 2014 sweep-net sampling. The main effects of the variables were examined but interactions were not included in the models. Main treatment means for visual observations and all sampling methods were separated using Tukey's Honestly Significant Difference Test (SAS Institute 2010).

Results

Visual Observations: The Effect of Plant Type, Observation Date, and Observation Time on Pollinator Taxa Visitation in Summer 2013. Potential pollinators observed during visual observations consisted of bumble bees (*Bombus* spp. Latreille), small bees (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say), and other bees (i.e. *Xylocopa* spp. Latreille and *Apis mellifera* L.), Dolichopodidae, Syrphidae, Muscidae, Mordellidae, Hesperiidae, Pieridae, *Junonia coenia* Hübner, and "All Pollinators Combined". For bumble bees, plant type ($F_{73,4391}$ = 13.14, *P* = <0.0001), observation date ($F_{13,4391}$ = 2.76, *P* = 0.0007), and observation time ($F_{1,4391}$ = 8.51, *P* = 0.0035) significantly influenced bumble bee visitation with plant type, Anise Hyssop 'Black Adder', (0.90±0.14) (*Agastache* (Pursh) Kuntze 'Black Adder', plant type 2) visited most often (Table 4.2 and Table 4.3). Plant type ($F_{73,4391}$ = 6.00, *P* = <0.0001) and observation date ($F_{13,4391}$ = 6.18, *P* = <0.0001) were also significant for small bees (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say) (Table 4.2). In fact, small bees preferred Rudbeckia 'Indian Summer' (0.22 ± 0.05) (*Rudbeckia hirta* L. 'Indian Summer', plant type 31) and other plant taxa. For other bees, plant type ($F_{73,4391}$ = 3.73, *P* = <0.0001) and observation date ($F_{13,4391}$=3.10, *P* = <0.0001) were significant with this taxa primarily visiting Coleus Fuseables (1.35 ± 0.35) (*Solenostemon scutellariodes* L., plant type 18) (Table 4.2 and Table 4.3).

Dipterans observed included Dolichopodidae, Syrphidae, and Muscidae. Among dipteran potential pollinators, dolichopodid flies were significant for plant type ($F_{73,4391}$ = 4.87, *P* = <0.0001) and observation date ($F_{13,4391}$ = 2.16, *P* = 0.0088), preferring Queen Lily Ginger 'Emperor' (0.22 ± 0.05) (*Curcuma petiolata* Roxburgh 'Emperor', plant type 28). Likewise, plant type ($F_{73,4391}$ = 2.89, *P* = <0.0001) and observation date ($F_{13,4391}$ = 3.71, *P* = <0.0001) were also significant for syrphid flies with this taxa found on Trumpet Honeysuckle among other plant taxa (0.39 ± 0.24) (*Lonicera sempervirens* L. 'Major Wheeler', plant type 74) (Table 4.2 and Table 4.3). Plant type ($F_{73,4391}$ = 3.32, *P* = <0.0001) and observation date ($F_{13,4391}$ = 1.94, *P* = 0.0221) were significant predictors of muscid occurrence. These flies were found in high numbers on Coreopsis 'Red Shift'

(0.12 ± 0.04) (*Coreopsis auriculata* L. ‘Red Shift’, plant type 47) and Coreopsis ‘Snowberry’ (0.12 ± 0.04) (*Coreopsis auriculata* L. 'Snowberry’, plant type 48) (Table 4.3) as well as other plant taxa.

Plant type affected potential pollinators including mordellids ($F_{73,4391}$ = 8.74, *P* = <0.0001), hesperiids (i.e. *Hylephila phyleus* Drury and *Epargyreus clarus* Cramer) ($F_{73,4391}$ = 2.63, *P* = <0.0001), pierids (i.e. *Pieris rapae* L. *and Phoebis sennae* L.) ($F_{73,4391}$ = 11.13, *P* = <0.0001), and the common buckeye butterfly (*J. coenia*) occurrence ($F_{73,4391}$ = 2.61, *P* = <0.0001) (Table 4.2). Gaura ‘Passionate Blush’ (0.41 ±0.10) (*Gaura lindheimeri* Engelm ‘Passionate Blush’, plant type 21) most frequently visited by mordellids. Anise Hyssop ‘Black Adder’ (0.08 ±0.04) (*Agastache* ‘Black Adder’, plant type 2) and Lantana ‘Ms. Huff’ (0.08 ±0.04) (*Lantana camara* L. ‘Ms. Huff’, plant type 25) were among the most frequently visited by hesperiids (Table 4.3). Pierid butterflies visited Bronze Fennel (0.18 ±0.05) (*Foeniculum vulgare* Miller, plant type 10) whereas common buckeye butterflies were found on Trumpet Honeysuckle (0.14 ± 0.07) (*Lonicera sempervirens* 'Major Wheeler', plant type 74) as well as other plant taxa (Table 4.3). Observation date was significant for mordellids ($F_{13,4391}$ = 3.62, *P* = <0.0001), hesperiids ($F_{13,4391}$ = 2.76, *P* = 0.0006), and *J. coenia* ($F_{13,4391}$ = 1.80, *P* = 0.0374). Moreover, observation time affected occurrence of hesperiids ($F_{1,4391}$ = 9.61, *P* = 0.0019) and *J. coenia* ($F_{1,4391}$ = 4.14, *P* = 0.0419). For “All Pollinators Combined” group, plant type ($F_{73,4391}$ = 8.44, *P* = <0.0001) and observation date ($F_{13,4391}$ = 3.81, *P* = <0.0001) were significant for this group. Among plant taxa most preferred by this group was Anise Hyssop ‘Black Adder’ (1.13 ± 0.14) (*Agastache* ‘Black Adder’, plant type 2) (Table 4.1 and 4.2).

Visual Observations: The Effect of Plant Type, Observation Date, and Observation Time on Beneficial Insect Taxa Visitation in Summer 2013. Potential beneficial insect taxa observed included Asilidae, Cantharidae, Lampyridae, Miridae (i.e. *Lygus* spp. Hahn), Pentatomidae (i.e. *Euthyrhynchus* spp. L.), Oecanthinae, *Geocoris punctipes* Say. Plant type was a significant predictor for occurrence of Asilidae ($F_{73,4391}$ = 2.05, *P* = <0.0001), Cantharidae ($F_{73,4391}$ = 3.92, *P* = <0.0001), Lampyridae ($F_{73,4399}$ = 4.37, *P* = <0.0001) and Miridae ($F_{73,4391}$ = 8.74, *P* = 0.0006) (Table 4.2). Asilid flies commonly visited Trumpet Honeysuckle (0.03 ± 0.02) (*Lonicera sempervirens* 'Major Wheeler', plant type 74) (Table 4.4). Among those preferred, Anise Hyssop 'Black Adder' (0.13 ± 0.04) (*Agastache* 'Black Adder', plant type 2) and Lamb's Ear (0.13 ±0.06) (*Stachys byzantine* Koch, plant type 63) were commonly visited by predatory cantharid beetles. Lampyridae visited Gaura 'Passionate Blush' (0.13 ±0.04) (*Gaura lindheimeri* 'Passionate Blush', plant type 21) and other plants (Table 4.4). Yarrow 'Coronation Gold' (*Achillea filipendulina* Lamarck 'Coronation Gold', plant type 19) (0.17 ±0.06) was among the most frequently visited by mirids (Table 4.4). Furthermore, observation date affected Cantharidae ($F_{13,4391}$ = 2.47, *P* = 0.0024), Lampyridae ($F_{13,4390}$ = 3.63, P = <0.0001), and Miridae ($F_{13,4391}$ = 3.62, *P* = 0.0406) and observation time influenced Miridae ($F_{1,4391}$ = 1.44, *P* = 0.0249) (Table 4.2).

Plant type was also significant for Oecanthinae ($F_{73,4391}$ = 3.97, *P* = <0.0001), Pentatomidae ($F_{73,4390}$ = 2.08, P = <0.0001), and *G. punctipes* ($F_{73,4391}$ = 2.78, *P* = <0.0001) (Table 4.2). Among the most frequently visited, Oecanthinae were commonly found on the Butterfly Bush (0.24 ±0.09) (*Buddleia* L., plant type 11) and predatory stink bugs on Bronze Fennel (0.07 ±0.03) (*Foeniculum vulgare*, plant type 10) (Table 4.4).

Gaura ‘Passionate Blush’ (0.13 ±0.05) (*Gaura lindheimeri* ‘Passionate Blush’, plant type 21), was among those preferred by *G*. *punctipes* (Table 4.5). Significance among observation date was determined for Oecanthinae ($F_{13,4391}$ = 2.63, *P* = 0.0012) and *G*. *punctipes* ($F_{13,4391}$ = 3.11, *P* = <0.0001) (Table 4.2). For the “All Beneficial Insects Combined” group, plant type ($F_{73,4389}$ = 6.18, *P* = <0.0001) and observation date ($F_{73,4389}$ = 4.79, *P* = <0.0001) were significant with Gaura ‘Passionate Blush’ (0.40 ±0.08) among plant taxa commonly visited (*Gaura lindheimeri* ‘Passionate Blush’, plant type 21) (Table 4.4).

Visual Observations: The Effect of Plant Type and Observation Date on Pollinator Taxa Visitation in Fall 2013. Potential pollinators observed included bumble bees (*Bombus* spp. Latreille), small bees (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say), and other bees (i.e. *Xylocopa* spp. Latreille and *Apis mellifera* L.), Dolichopodidae, Syrphidae, Hesperiidae, Pieridae, *Vanessa* spp. Fabricius, *Papilio glaucus* L., and *Junonia coenia* Hübner. Plant type ($F_{75,3110}$ = 6.61, *P* = <0.0001) and observation date ($F_{18,3110}$ = 2.06, *P* = 0.0052) affected occurrence of bumble bees. Anise Hyssop ‘Raspberry Nectar’ (*Agastache* (Pursh) Kuntze 'Raspberry Nectar’, plant type 41) was among preferred plant taxa by bumble bees (1.82 ±1.72) (Table 4.6 and Table 4.7). Significance among plant type ($F_{75,3109}$ = 4.28, *P* = <0.0001) and date ($F_{18,3109}$ = 1.78, *P* = 0.0220) were also determined for small bees (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say), found on Celosia (*Celosia spicata* L., plant type 16) (1.21 ± 0.31) and other plant taxa (Table 4.6 and Table 4.7). Plant type ($F_{75,3111}$ = 7.67, *P* = <0.0001) and date ($F_{18,3111}$ = 3.45, *P* = <0.0001) were significant predictors of other bee occurrence. Among most visited by other bees was Coleus Fuseables (*Solenostemon scutellariodes,* plant type 18*)* (1.35 ± 0.35) (Table 4.6 and Table 4.7).

Of the dipteran pollinators, occurrence of dolichopodid flies were significantly affected by plant type ($F_{75,3111}$ = 1.88, *P* = <0.0001) and date ($F_{18,3111}$ = 3.06, *P* = <0.0001). Significance among plant type ($F_{75,3110}$ = 2.52, *P* = <0.0001) and date ($F_{18,3110}$ = 7.31, *P* = <0.0001) were determined for syrphid flies. Gaura 'Passionate Blush (*Gaura lindheimeri* 'Passionate Blush', plant type 21) (0.48 ± 0.20) (Table 4.6 and Table 4.7) was among the most commonly visited by Syrphidae. Hesperiidae was also significant for plant type ($F_{75,3090}$ = 5.07, *P* = <0.0001) and date ($F_{18,3090}$ = 2.23, *P* = 0.0021) with these lepidopterans visiting Lantana 'Mozelle' (*Lantana camara* L. 'Mozelle' , plant type 24) and other plant taxa (1.00 ± 0.29). Futhermore, plant type ($F_{75,3111}$ = 6.73, *P* = <0.0001) and date ($F_{18,3111}$ = 3.96, *P* = <0.0001) were significant predictors for occurrence of Pieridae with this pollinator visiting Hummingbird Plant (*Dicliptera suberecta* Jussieu, plant type 37*)* as well as other floral resources (1.17 ± 0.33) (Table 4.6 and Table 4.7).

Vanessa spp. ($F_{75,3111}$ = 1.48, *P* = 0.0049), *P. glaucus* ($F_{75,3111}$ = 1.81, *P* = <0.0001), and *J. coenia* ($F_{75,3111}$ = 2.10, *P* = <0.0001) were all significant among plant type (Table 4.6). Among plant taxa most visited by *Vanessa sp*. was Lamb's Ear (*Stachys byzantine,* plant type 67) (0.13 ± 0.13). For the *P. glaucus*, the Butterfly Bush (*Buddleia*, plant type 11) was among plant taxa preferred (0.11 ± 0.06) and *J. coenia* visited Celosia (*Celosia spicata,* plant type 16*)* (0.19 ± 0.08) as well as other plant taxa (Table 4.7). For the "All Pollinators Combined" category, plant type ($F_{75,3086}$ = 10.22, *P* = <0.0001) and date ($F_{18,3086}$ = 3.43, P = <0.0001) significant indicators of occurrence (Table 4.6).

Among frequently visited flower types were Celosia (*Celosia spicata,* plant type 16*)* (5.21 ± 0.80) and Coleus Fuseables (*Solenostemon scutellariodes,* plant type 18) (4.61 ± 0.71) (Table 4.5).

Pan Trapping: The Effect of Pan Trap Type and Sampling Date on Pollinator Taxa in Summer 2013. For honeybees, bumble bees, and carpenter bees (F: Apidae), sampling date was a significant predictor of occurrence ($F_{2,136}$ = 6.37, *P* = 0.0024) (Table 4.8). These pollinators were collected more abundantly on June 23, 2013 (0.25 ± 0.08) (Table 4.9). Sampling date also significant affected occurrence of chironomid flies which were collected primarily from pan traps on June 21, 2013 (0.07 ± 0.05). Significance among pan trap sampling date ($F_{2,136}$ = 5.17, *P* = 0.0070), and pan trap type ($F_{13,136}$ = 4.21, *P* = <0.0001) were found for mordellids (Table 4.8). These coleopterans were collected on June 23, 2013 (3.67 ± 1.33) as well as other sampling dates and predominately in yellow bowls on the ground (13.1 ± 6.68) and yellow bowls on a stand (9.25 ± 4.11) (Table 4.9 and Table 4.11).

Occurrence of small bees (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say), syrphid flies, and other flies were significantly influenced by sampling date and pan trap type (Table 4.8). Small bees were found more abundantly on June 23, 2013 (2.67 ± 0.72). Likewise, hoverflies were abundant in samples from June 23, 2013 (0.27 ± 0.10) and June 21, 2013 (0.29 ± 0.12). Other flies were collected in high numbers on June 23, 2013 (0.61 ± 0.12) as well as other sampling dates (Table 4.9). Yellow bowls on the ground (trap type 5) was among traps preferred by syrphid flies (1.25 ± 0.45) and other flies (1.25 ± 0.41). Among traps commonly visited by small bees was yellow bowls on the ground (5.38 ± 1.69) and yellow bowls on a stand (7.13 ± 3.65)

(Table 4.11). Pan trap sampling date ($F_{2,136}$ = 8.63, *P* = 0.0003) and pan trap type ($F_{13,136}$ = 13.18, *P* = <0.0001) was significant for the "All Pollinators Combined" assemblage with these insects collected abundantly on June 23, 2013 (16.3 ± 4.53) and from yellow bowls on the ground (72.5 ± 19.1) (trap type 5) (Table 4.8, 4.9, 4.11).

Trap type affected occurrence of Cephidae ($F_{13,136}$ = 2.98, *P* = 0.0009), Chalcidoidea ($F_{13,136}$ = 4.50, *P* = <0.0001), Dolichopodidae ($F_{13,136}$ = 7.56, *P* = <0.0001), Hesperiidae ($F_{13,136}$ = 2.91, *P* = 0.0011), and Tephritidae ($F_{13,136}$ = 2.87, *P* = 0.0013) (Table 4.8). Cephidae (0.25 ± 0.16), Chalcidoidea (1.86 ± 0.77), and Dolichopodidae (33.9 ± 13.3) found in yellow bowl traps on the ground (trap type 5). However, Hesperiidae (0.25 ± 0.16) were collected in high numbers from yellow bowls on the stand (trap type 13) (Table 4.11).

Pan Trapping: The Effect of Pan Trap Type and Sampling Date on Beneficial Insect Taxa in Summer 2013. Pan trap type was significant for beneficial insects: Carabidae ($F_{13,136}$ = 1.99, *P* = 0.0275), Formicidae ($F_{13,136}$ = 2.66, *P* = 0.0027), Lampyridae ($F_{13,136}$ = 2.31, *P* = 0.0091), and Staphylinidae ($F_{13,136}$ = 2.37, *P* = 0.0074) (Table 4.8). Among trap types preferred was yellow bowls on a stand for carabid (0.25 ± 0.16) and lampyrid beetles (0.25 ± 0.16) (trap type 13) (Table 4.11). The staphylinid beetles were captured in yellow cups on the ground (3.00 ± 1.46) and other traps (trap type 9) (Table 4.11). Significance among trap type ($F_{13,136}$ = 3.64, *P* = <0.0001) was determined for "All Beneficial Insects Combined" with this group captured in high numbers in yellow cups on the ground (4.72 ± 1.48) (trap type 9) as well as other trap types (Table 4.11). Sampling date only affected occurrence of ($F_{2,136}$ = 4.69, *P* = 0.0110)

Formicidae, collected in samples from June 23 (0.82 ± 0.20) and June 25, 2013 (1.17 ± 0.26) (Table 4.8 and 4.9).

Pan Trapping: The Effect of Pan Trap Type and Sampling Date on Plant-Feeding Insect Taxa in Summer 2013. Pan trap sampling date affected occurrence of Plataspidae ($F_{2,136}$ = 4.03, *P* = 0.0202) and Thripidae ($F_{2,136}$ = 3.35, *P* = 0.0383) (Table 4.8). Sampling date, June 23, 2013 (0.44 ± 0.32), was among those preferred by Thripidae (Table 4.9). Occurrence of Cicadellidae, Aphididae, and "All Plant-Feeding Insects Combined" were significantly affected by sampling date and pan trap type (Table 4.8). Aphididae (0.39 ± 0.14) and "All Plant-Feeding Insects Combined" (4.90 ± 0.96) were abundantly found in samples from June 23, 2013 and other sampling dates. Cicadellids were found more abundantly on June 23, 2013 (2.43 ± 0.78) and June 25, 2013 (1.98 ± 0.62) (Table 4.9). Cicadellidae (15.4 ± 2.43), Aphididae (2.00 ± 0.65), and "All Plant-Feeding Insects Combined" (19.3 ± 2.82) were collected in yellow bowl pan traps located on the ground (trap type 5) with Aphididae also frequently occurring in yellow bowls on a stand (1.50 ± 0.63) (trap type 13) (Table 4.11). Significance among trap type was also determined for Curculionidae ($F_{13,136}$ = 1.86, *P* = 0.0419) and Cercopoidea ($F_{13,136}$ = 3.42, *P* = 0.0002). Curculionid beetles were found in high numbers in blue bowls on stands (1.13 ± 0.85) (trap type 3) whereas cercopoids were sufficiently captured in yellow bowls on the ground (0.62 ± 0.32) (trap type 5) (Table 4.11).

Pan Trapping: The Effect of Sampling Date on Pollinating, Beneficial and Plant-Feeding Insect Taxa in Summer 2014. Sampling date was a significant predictor for occurrence of chironomid flies ($F_{6,55}$=3.48, *P* = 0.0065), dolichopodid flies ($F_{6,55}$ = 6.33, *P* = <0.0001), syrphid flies ($F_{6,55}$=3.66, *P* = 0.0048), and other flies ($F_{6,55}$ = 2.55, *P*

= 0.0327) (Table 4.12). Among other sampling dates, July 15, 2014 (4.88 ± 1.09), collected large numbers of Chironomidae (Table 4.20). Dolichopodidae were found abundantly in traps collected on July 15, 2014 (45.8 ± 7.73) and Syrphidae were captured on July 1, 2014 (1.75 ± 0.56) and other sampling dates (Table 4.13).

Sampling date also affected occurrence of mordellid beetles ($F_{6,55}$ = 3.27, P = 0.0093) and small bees (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say) ($F_{6,55}$ = 7.12, P = <0.0001) (Table 4.12). Among those sampling dates preferred, July 15, 2014 collected Mordellidae (1.63 ± 0.77) and small bees (5.13 ± 0.69) with small bees also abundantly collected on July 22 (9.00 ± 1.52) (Table 4.13). Significance among pan trap sampling date was also determined for the "All Pollinators Combined" ($F_{6,55}$ = 6.38, P = <0.0001) with these taxa captured abundantly in samples from July 15, 2014 (60.6 ± 7.81) as well as other sampling dates (Table 4.12 and 4.13).

For the beneficial insects sampled, pan trap sampling date significantly influenced population occurrence of Braconidae ($F_{6,55}$ = 2.36, P = 0.0458) and Oecanthinae ($F_{6,55}$ = 2.77, P = 0.0224) (Table 4.12). Braconid wasps dominated trap catches on July 1, 2014 (0.75 ± 0.25) and other sampling dates. Oecanthinae were found most abundantly in samples from July 15 (0.13 ± 0.13) and July 28, 2014 (0.75 ± 0.41). Other beneficial insect taxa surveyed were not significantly abundant throughout the four garden replicates (Table A.4). However, pan trap sampling date was a significant predictor for occurrence of "All Beneficial Insects Combined" ($F_{6,55}$ = 2.91, P = 0.0176) with July 1, 2014 (4.88 ± 1.09) among sampling dates captured. (Table 4.12 and Table 4.13).

Sampling date affected occurrence of Cicadellidae ($F_{6,55}$ = 4.55, P = 0.0002), Aphididae ($F_{6,55}$ = 5.74, P = 0.0002), and Thripidae ($F_{6,55}$ = 3.22, P = 0.0102) (Table

4.12). Sampling dates on which cicadellids were captured included July 1, 2014 (16.0 ± 2.59) while aphids dominated trap catches collected August 4, 2014 (1.13 ± 0.40). Thrips were collected in abundance from samples on June 24, 2014 (1.75 ± 0.70) and other sampling dates (Table 4.13). Significance among pan trap sampling date ($F_{6,55} = 6.00$, $P =$ <0.0001) was determined for "All-Plant-Feeding Insects Combined" with these taxa collected primarily on June 24, 2014 (17.4 ± 4.23) and July 1, 2014 (17.3 ± 2.51) (Table 4.12 and Table 4.13).

Pan Trapping: Bee Species Collected in Summer 2013 and 2014. There were 214 bees sampled during 2013 and 2014 pan trapping with 16 species of bees collected (Table 4.14 and Table 4.15). These consisted of *Agapostemon virescens* Fabricius, *Augochlora pura pura* Say, *Bombus griseocollis* DeGeer, *Bombus impatiens* Cresson, *Halictus ligatus* Say, *Halictus parrallelus* Say, *Holcopasites calliopsidis* Linsley, *Lasioglossum (dialictus) coreopsis* Robertson, *Lasioglossum (dialictus) disparile* Cresson, *Lasioglossum (dialictus) illnoensis* Robertson, *Lasioglossum (dialictus) imitatum* Smith, *Lasioglossum (dialictus) mitchelli* Gibbs, *Lasioglossum (dialictus) tegulare* Robertson, *Lasioglossum (hemihalictus) lustrans* Cockerell, *Melissodes comptoides* Robertson, *Ptilothrix bombiformis* Cresson (Table 4.14 and Table 4.15). *Lasioglossum (dialictus) imitatum* was the most abundant species (116), predominating traps sampled on July 22, 2014 (33) (Table 4.14). *Lasioglossum (dialictus) imitatum* was captured primarily in yellow bowls on the ground (115) (Table 4.15). species collected *Halictus ligatus* (54) were also found in high numbers, with this species dominating trap catches from June 20-June 25, 2013 (34) (Table 4.14). The majority of *Halictus ligatus*

(40) were captured in the yellow bowl traps located on the ground during the 2013 and 2014 (Table 4.15).

Sweep-Net Sampling: The Effect of Plant Type and Sampling Date on Pollinator Taxa in Summer 2014. Significance among plant type ($F_{38,878}$ = 2.31, *P* = <0.0001) and date ($F_{6,878}$ = 4.75, *P* = <0.0001) were found for Dolichopodidae (Table 4.17). These pollinating dipterans were found abundantly during sampling dates: June 26 (0.22±0.06), July 8 (0.15±0.04), and July 22, 2014 (0.13±0.04) (Table 4.18). Queen Ginger Lily 'Emperor' (0.56±0.25) (*Curcuma petiolata* 'Emperor', plant type 28) was among plant taxa preferred by dolichopodid flies (Table 4.19). Bumble bees ($F_{38,878}$ = 4.46, *P* = <0.0001) and large carpenter bees ($F_{38,878}$ = 3.60, *P* = <0.0001) also had significance among plant type (Table 4.17). Bumble bees preferred Mexican Petunia 'Purple Showers' (*Ruellia brittoniana* Wright 'Purple Showers', plant type 33) to all other plant types (0.13±0.13). Moreover, carpenter bees were found abundantly on Yarrow 'Coronation Gold' (*Achillea filipendulina* 'Coronation Gold', plant type 19) (0.72±0.44) and Yarrow 'Sunny Seduction' (*Achillea millefolium* L. 'Sunny Seduction', plant type 35) (0.22±0.14) (Table 4.19). Plant type ($F_{38,878}$ = 1.81, *P* = 0.0022) and sampling date ($F_{6,878}$ = 2.77, *P* = 0.0112) were significant for Mordellidae. Mordellid beetles were found abundantly in sweep-net samples collected on dates: June 10 (0.21±0.11), June 17 (0.10 ± 0.03), July 8 (0.08 ± 0.03), and June 26 (0.07 ± 0.04) (Table 4.18). Sampling date was also a significant predictor of muscid ($F_{6,878}$ = 2.13, *P* = 0.0478), ulidiid ($F_{6,878}$ = 2.10, *P* = 0.0513), and syrphid fly ($F_{6,878}$ = 4.30, *P* = 0.0003) occurrence (Table 4.17). Muscidae were found in high numbers on June 26 (0.12±0.03) and other sampling dates. Sampling date, June 17 (0.19±0.05), were among those in which large numbers of Syrphidae were captured (Table 4.18).

Plant type also affected occurrence of syrphid flies ($F_{38,878}$ = 3.03, *P* = <0.0001) and small bees ($F_{38,878}$ = 3.95, *P* = <0.0001) which include plasterer bees (F: Colletidae), mining bees (F: Andrenidae), leaf-cutter bees (F: Megachilidae), and sweat bees (F: Halictidae) (Table 4.14). Small bees commonly visited Anise Hyssop 'Black Adder' (*Agastache* 'Black Adder', plant type 2) (0.41± 0.15) over other plant taxa sampled (Table 4.19). Likewise, sampling date was significantly influenced small bee occurrence ($F_{6,878}$ = 11.9, *P* = <0.0001), collecting this taxa on July 22 (1.43± 0.25) (Table 4.18). Significance among plant type was determined for *A. mellifera* ($F_{38,878}$ = 1.45, *P* = 0.0418), *Hemaris* spp. ($F_{38,878}$ = 1.79, *P* = 0.0026), *H. phyleus* ($F_{38,878}$ = 2.00, *P* = 0.0004), and *J. coenia* ($F_{38,878}$ = 1.53, *P* = 0.0233) (Table 4.17). *A. mellifera* preferred Bee Balm 'Raspberry Wine' (*Monarda didyma* L. 'Raspberry Wine', plant type 5) (0.30± 0.13). Brazilian Verbena (*Verbena bonariensis* L., plant type 9) (0.05± 0.05) was commonly visited by *H. phyleus* and Lantana 'Ms. Huff' (*Lantana camara* 'Ms. Huff', plant type 25) (0.40 ± 0.18) was among plant taxa preferred by *J. coenia* (Table 4.19). Sampling date significantly influenced occurrence of Yponomeutidae ($F_{6,878}$ = 2.91, *P* = 0.0081), *Trypoxylon politum* Drury ($F_{6,878}$ = 2.54, *P* = 0.0190), and *J. coenia* ($F_{6,878}$ = 2.90, *P* = 0.0083) (Table 4.25). *J. coenia* was found on June 10 (0.05± 0.02) and other sampling dates whereas *T. politum* were collected abundantly on July 22 (0.01± 0.01) (Table 4.18). Plant type and date were significant predictors of occurrence of "All Pollinators Combined", captured on July 22 (1.83± 0.27) and other sample dates. Celosia (*Celosia* *spicata,* plant type 16) was among plant taxa preferred by "All Pollinators Combined" (3.89± 1.12) (Table 4.17, 4.18, and 4.19).

Sweep-Net Sampling: The Effect of Plant Type and Sampling Date on Beneficial Insect Taxa in Summer 2014. Beneficial insect abundance and diversity was also measured through sweep net samples. Plant type ($F_{38,877}$ = 2.01, *P* = 0.0004) and sampling date ($F_{6,877}$ = 4.09, *P* = 0.0005) significantly affected Araneae (Table 4.17). Among other dates, June 17 (0.31 ± 0.07) collected large numbers of Araneae (Table 4.18). Plant type ($F_{38,878}$ = 1.62, *P* = 0.0109) and sampling date ($F_{6,878}$ = 2.60, *P* = 0.0167) were also significant for cantharid beetles (Table 4.17). For Formicidae, significance among sampling date ($F_{6,877}$ = 2.13, *P* = 0.0479) was determined (Table 4.17). Plant type ($F_{38,878}$ = 4.42, *P* = <0.0001) and sampling date ($F_{6,878}$ = 3.20, *P* = 0.0041) were significant predictors of mirid occurrence, being found in high numbers on June 17 (0.44± 0.11) as well as other sample dates (Table 4.18).

Plant type ($F_{38,878}$ = 1.55, *P* = 0.0192) and sampling date ($F_{6,878}$ = 5.18, *P* = <0.0001) significantly affected nabid occurrence. Sampling date, July 22 (0.20 ± 0.05), were among dates in which Nabidae were commonly collected (Table 4.17 and Table 4.18). Lemon Balm (*Melissa officinalis* L., plant type 26) (0.85± 0.85) was preferred by Nabidae when compared to other plant taxa (Table 4.20). Plant type was a significant predictor for occurrence of Pentatomidae ($F_{38,878}$ = 2.28, *P* = <0.0001) and *G. punctipes* ($F_{38,878}$ = 4.81, *P* = <0.0001) (Table 4.17). For parasitic Hymenoptera ($F_{6,878}$ = 2.54, *P* = 0.0190), sampling date significantly affected occurrence (Table 4.17). Plant type ($F_{38,878}$ = 2.98, *P* = <0.0001) and sampling date ($F_{6,878}$ = 4.41, *P* = 0.0002) were significant for "All

Beneficial Insects Combined" (Table 4.17). These taxa were largely found in samples collected on June 17 (1.53± 0.24), June 26 (1.59 ± 0.44), July 3 (1.14 ± 0.18) and other sampling dates (Table 4.18). Three-Lobed Coneflower (*Rudbeckia triloba* L., plant type 32) (4.05± 2.08) was among plant taxa preferred by "All Beneficial Insects Combined" (Table 4.20).

Sticky Trapping: The Effect of Sticky Trap Height and Sampling Date on Pollinator Taxa in Summer 2014. Sticky trap height ($F_{1,63}$ = 11.29, *P* = 0.0015) and sampling date ($F_{7,63}$ = 5.86, *P* = <0.0001) were significant predictors of dolichopodid occurrence (Table 4.21). In fact, Dolichopodidae preferred the four-foot sticky traps (4.41±0.81) over the two-foot traps (1.97±0.42) (Table 4.22). Dolichopodidae were collected abundantly on June 10-June 17 (8.25±2.24) and June 3-June 10 (5.00±1.27) (Table 4.23). Trap height was also significant ($F_{1,63}$ = 11.10, *P* = 0.0016) for chironomid flies (Table 4.21). Chironomidae preferred the two-foot sticky trap height (29.8±4.25) as compared to four-foot traps (17.9±1.91) (Table 4.22). Sampling date was significant ($F_{7,63}$ = 2.16, *P* = 0.0528) for Mordellidae. Trap height ($F_{1,63}$ = 4.99, *P* = 0.0297) significantly influenced the "All Pollinators Combined" group, preferring two-foot traps (34.1±4.30) over the four-foot traps (25.6±2.03) (Table 4.22). Occurrence of syrphid flies, other flies, and mordellid beetles were not significantly affected by trap height and occurrence of syrphid flies and other flies were not influenced by sticky trap sampling date (Table 4.21).

Sticky Trapping: The Effect of Sticky Trap Height and Sampling Date on Beneficial Insect Taxa in Summer 2014. Sampling date was a significant predictor of parasitic Hymenoptera ($F_{7,63}$ = 4.56, P = 0.0005) and "All Beneficial Insects Combined" occurrence ($F_{7,63}$ = 3.98, P = 0.0015) (Table 4.21). Parasitic Hymenoptera were captured primarily on July 22-July 28 (7.63±1.25), June 3-June 10 (5.50±0.78), July 8-July 15 (4.63±1.26), and July 15-July 22 (4.75±1.10) (Table 4.23). The "All Beneficial Insects Combined" group was collected abundantly on July 22-July 28 (7.63±1.25), June 3-June 10 (5.63±0.80), July 8-July 15 (4.88±1.26), and July 15-July 22 (4.88±1.09) (Table 4.23). Occurrence of Formicidae, Miridae, and Pentatomidae were not influenced by sticky trap height (Table 4.22) and trap sampling date (Table 4.23).

Sticky Trapping: The Effect of Sticky Trap Height and Sampling Date on Plant-Feeding Insect Taxa in Summer 2014. For cicadellid occurrence, sticky trap height was a significant predictor ($F_{1,63}$ = 6.36, P = 0.0147) (Table 4.21). Cicadellidae preferred the four-foot sticky traps (4.97 ± 0.57) over the two-foot sticky traps (3.06 ± 0.47) (Table 4.22). Trap height also affected occurrence of "All Plant-Feeding Insects Combined" ($F_{1,63}$ = 6.02, P = 0.0175) (Table 4.21). This group was found more abundantly on the four-foot sticky traps (5.56 ± 0.59) than the two-foot traps (3.63 ± 0.49) (Table 4.22). Sampling date significantly influenced ($F_{7,63}$ = 2.31, P = 0.0395) chrysomelid occurrence, however, was not significantly influenced by sticky trap height (Table 4.21). Sticky trap height (Table 4.22) and trap sampling date (Table 4.23) were not significant predictors of Rhyparochromidae, Curculionidae, and Elateridae occurrence.

Discussion

In this study, we set out to provide detailed information on the attractiveness of a wide selection of ornamental floral resources to pollinators, natural enemies, and plant-feeding insects. Woltz et al. (2012) affirms complex landscapes with flowering plants provide overwintering refuges, alternative hosts and prey, and nectar and pollen resources for pollinating and beneficial arthropods. If pollinator and natural enemy populations are supported throughout the season by floral resources, growers and homeowners may receive increased pollination and biological control services.

Visual observations and sweep-net sampling revealed occurrences of Hymenoptera (Apidae, small bees, parasitic wasps, and Formicidae); Diptera (Asilidae, Dolichopodidae, Syrphidae, and Ulidiidae); Lepidoptera (Hesperiidae, Pieridae, *H. phyleus*, *J. coenia*, *P. glaucus*, and *Vanessa* spp.); Hemiptera (Miridae, Nabidae, Pentatomidae, and *G. punctipes*); Orthoptera (Oecanthinae); and Araneae. Based on two series of visual observations and sweep-net sampling, the selected plants attracted a large diversity of arthropod populations. The plants most attractive to pollinators and natural enemies were *Achillea* 'Coronation Gold', *Achillea* 'Sunny Seduction', *Agastache* 'Black Adder', *Agastache* 'Raspberry Nectar', *Buddleia*, *Coreopsis* 'Red Shift', *Coreopsis* 'Snowberry', *Celosia spicata*, *Curcuma* 'Emperor', *Dicliptera*, *Foeniculum vulgare*, *Gaura* 'Passionate Blush', *Lantana* 'Mozelle', *Lantana*. 'Ms. Huff', *Lonicera* 'Major Wheeler', *Melissa officinalis*, *Monarda* 'Raspberry Wine', *Rudbeckia* 'Indian Summer', *Rudbeckia triloba*, *Ruellia* 'Purple Showers', *Stachys byzantine*, *Solenostemon scutellariodes*, and *Verbena bonariensis*.

Our findings are consistent with previous studies which recommend many of these plant taxa as primary attracting-plant species because of their heavy pollen load, abundant nectar, and the overwintering sites they provide natural enemies and pollinators (Bruner et al. 2008, Feldman and Haber 1998, Forehand et al. 2006, Fuentes-Granados et al. 1998, Korcz 2001, Langellotto and Matteson 2011, Ricciardelli d'Albore 1997, Taber 2003, Thorp et al. 2005, Sadeghi 2008, and Shepherd et al. 2008). Increasing concerns on the provision of agricultural and urban landscapes for native pollinators and beneficial insects have initiated conservation activities on managed land (Tuell et al. 2008). Plants reported here as being attractive to pollinators and natural enemies can help land managers and homeowners select appropriate insect-attracting plant species for use in ornamental landscapes and conservation areas.

This study was designed to survey occurrences of beneficial and pollinating arthropods as well as to determine influence of plant parameters on insect visitation so pan trap and sticky trap sampling was also employed. As floral records of pollinators and natural enemies can be difficult to obtain, a combination of methods were utilized, including pan trap and sticky trap sampling. Pan trapping is a traditional method that can be used to survey bees and other beneficial insects over multiple sites (Hudson 2013). Vrdoljak and Samways (2012) indicates pan trap color as important in determining species richness of pan trap catches, with color sets of high reflectance yellow and white generally having catches with the highest species richness. Insect groups collected through pan trapping included: Apidae, Asilidae, Carabidae, Dolichopodidae, Formicidae, Mordellidae, Staphylinidae, Syrphidae, and small bees (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say). Our findings conclude yellow bowl traps on the ground and stand as well as yellow cup traps on the ground can be successfully used to survey beneficial hymenopteran, coleopteran, dipteran, and lepidopteran insects. To monitor plant-feeding insects, yellow bowl traps on the ground and stand as well as blue bowls on a stand should be utilized. Campbell and Hanula

(2007) report use of blue pan traps to collect various beetle species that are attracted to shorter wavelengths of visible light (i.e. blue).

Based on recommendations from previous studies, sticky traps were also employed to capture minute arthropods (Boisclair et al. 2012, James et al. 2015, and Ozawa 1994). In our study, Chironomidae, Dolichopodidae, and parasitic Hymenoptera dominated trap catches. Our findings also indicated yellow sticky cards placed at two-foot and four-foot must be used in order to appropriately survey insect taxa. In future studies, a combination of sampling methods should be considered for use in order to effectively obtain an estimate of the pollinator and natural enemy communities visiting particular flowers and to survey insect occurrences.

Sampling date influenced occurrences of pollinating and beneficial insects in visual observation and other sampling methods. This is likely due to factors including floral preference and blooming time, environmental conditions (temperature, humidity, wind speed, etc.), and interactions with other arthropod taxa (Totland 1994). From June-November, temperatures averaged 27.7°C (2013) and 28.8°C (2014). Rainfall averaged 59.7 cm from June to November in 2013 and 46.5 cm in 2014. McCall and Primack (1992) suggests temperature, light, season, arthropod competition and flower characteristics are important variables that can influence insect visitation rates.

To the best of our knowledge, this study is the first to examine the response of pollinators and natural enemies to replicated plantings of ornamental plants suitable for southeastern landscapes. One of the first steps toward conservation of bees and other beneficial insects is to determine which plants will provide adequate resources at different times in the growing season and can be implemented in landscape by land managers and homeowners (Tuell et al. 2008). Using these data, recommendations can be provided on the applied use of flowering ornamental plants for pollinator and beneficial insect conservation purposes as well as sampling methods that should be employed to effectively survey beneficial insect communities.

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Table 4.1. List of plant type number, plant common name, and plant scientific name of plants observed from June 4- September 5, 2013 through visual observations and comparison assay for mean (± S.E.) of "All Pollinators Combined" and "All Beneficial Insects Combined" occurrence observed on seventy-four plant types in the UGA Butterfly and Conservation Gardens (n=4) (USDA hardiness zone 8a, Spalding Co., GA).

Plant Type Number	Plant Common Name	Plant Scientific Name	All Pollinators Combined	All Beneficial Insects Combined
1	Abelia 'Raspberry Perfusion'	*Abelia x grandiflora* 'Raspberry Profusion'	0.20 ± 0.06fghi	0.00 ± 0.00d
2	**Anise Hyssop 'Black Adder'**	***Agastache* 'Black Adder'**	**1.13 ± 0.14a**	0.05 ± 0.03de
3	Aster 'Wood's Pink'	Aster dumosus 'Wood's Pink'	0.55 ± 0.26bcdefgh	0.07 ± 0.03de
4	Astilbe 'Visions in Pink'	*Astilbe chinensis* 'Visions in Pink'	0.05 ± 0.03hi	0.03 ± 0.02de
5	Bee Balm 'Raspberry Wine'	*Monarda didyma* 'Raspberry Wine'	0.05 ± 0.03hi	0.03 ± 0.02de
6	Belamcanda 'Blackberry Lily'	*Belamcanda chinensis* 'Blackberry Lily'	0.45 ± 0.24cdefghi	0.00 ± 0.00e
7	Black Stem Elephant Ear	*Colocasia esculenta*	0.07 ± 0.03ghi	0.05 ± 0.03de
8	Threadleaf Bluestar	*Amsonia hubrichtii*	0.03 ± 0.02hi	0.08 ± 0.04cde
9	Brazilian Verbena	*Verbena bonariensis*	0.10 ± 0.04fghi	0.04 ± 0.02de
10	Bronze Fennel	*Foeniculum vulgare*	0.62 ± 0.13abcdef	0.13 ± 0.04bcde
11	Butterfly Bush	*Buddleia*	0.10 ± 0.05fghi	0.33 ± 0.11ab
12	Butterfly Ginger Lily	*Hedichium coronarium*	0.05 ± 0.03hi	0.02 ± 0.02de
13	Button Bush	*Cephalanthus occidentalis*	0.00 ± 0.00i	0.03 ± 0.02de
14	Cassia 'Wild Senna'	*Cassia herbecarpa* 'Wild Senna'	0.08 ± 0.04fghi	0.18 ± 0.06abcde
15	Catmint 'Walker's Low'	*Nepeta x faassenii*	0.74 ± 0.14abcde	0.02 ± 0.02de
16	Celosia	*Celosia spicata*	0.33 ± 0.11defghi	0.13 ± 0.06bcde
17	Chrysanthemum 'Cambodian Queen'	*Chrysanthemum dendranthema* 'Cambodian Queen'	0.00 ± 0.00i	0.00 ± 0.00e
18	Coleus Fuseables	*Solenostemon scutellariodes*	0.40 ± 0.08cdefghi	0.03 ± 0.02de
19	Yarrow 'Coronation Gold'	*Achillea filipendulina* 'Coronation Gold'	0.28 ± 0.09defghi	0.38 ± 0.09a
20	False Sunflower 'Summer Sun'	*Heliopsis scabra* 'Summer Sun'	0.18 ± 0.06fghi	0.08 ± 0.04cde
21	**Gaura 'Passionate Blush'**	***Gaura lindheimeri* 'Passionate Blush'**	1.07 ± 0.33ab	**0.40 ± 0.08a**
22	Hairy Loosestrife 'Firecracker'	*Lysimachia ciliata* 'Firecracker'	0.03 ± 0.02hi	0.02 ± 0.02de
23	Joe Pye Weed 'Gateway'	*Eupatorium purpureum* 'Gateway'	0.22 ± 0.05efghi	0.12 ± 0.04bcde
24	Lantana 'Mozelle'	*Lantana camara* 'Mozelle'	0.10 ± 0.04fghi	0.03 ± 0.02de
25	Lantana 'Ms. Huff'	*Lantana camara* 'Ms. Huff'	0.17 ± 0.06fghi	0.07 ± 0.03de
26	Lemon Balm	*Melissa officinalis*	0.00 ± 0.00i	0.00 ± 0.00e
27	Purple Coneflower 'Magnus'	*Echinacea purpurea* 'Magnus'	0.37 ± 0.12cdefghi	0.02 ± 0.02de
28	Queen Lily Ginger 'Emperor'	*Curcuma petiolata* 'Emperor'	0.27 ± 0.07defghi	0.22 ± 0.07abcd
29	Red Leaf Hibiscus	*Hibiscus acetosella*	0.02 ± 0.02hi	0.00 ± 0.00e
30	Rudbeckia 'Goldsturm'	*Rudbeckia fulgida* 'Goldsturm'	0.10 ± 0.05fghi	0.10 ± 0.06cde
31	Rudbeckia 'Indian Summer'	*Rudbeckia hirta* 'Indian Summer'	0.35 ± 0.07cdefghi	0.19 ± 0.07abcde
32	Three-Lobed Coneflower	*Rudbeckia triloba*	0.53 ± 0.12cdefghi	0.20 ± 0.09abcde
33	Mexican Petunia 'Purple Showers'	*Ruellia brittoniana* 'Purple Showers'	0.02 ± 0.02hi	0.02 ± 0.02de
34	Salvia 'Hot Lips'	*Salvia microphylla* 'Hot Lips'	0.41 ± 0.12cdefghi	0.07 ± 0.03de
35	Yarrow 'Sunny Seduction'	*Achillea millefolium* 'Sunny Seduction'	0.22 ± 0.06efghi	0.18 ± 0.05abcde
36	Snowbush	*Breynia nivosa*	0.00 ± 0.00i	0.00 ± 0.00e
37	Hummingbird Plant	*Dicliptera suberecta*	0.00 ± 0.00i	0.00 ± 0.00e
38	Lantana 'Pink Caprice'	*Lantana camara* 'Pink Caprice'	0.02 ± 0.02hi	0.03 ± 0.02de
39	Blue Beard 'First Choice'	*Caryopteris x clandonensis* 'First Choice'	0.00 ± 0.00i	0.00 ± 0.00e
40	Anise Hyssop 'Acapulco'	*Agastache mexicana 'Acapulco'*	0.78 ± 0.24abcd	0.05 ± 0.03de

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.1 (Continued). List of plant type number, plant common name, and plant scientific name of plants observed from June 4-September 5, 2013 through visual observations and comparison assay for mean (± S.E.) of "All Pollinators Combined" and "All Beneficial Insects Combined" occurrence observed on seventy-four plant types in the UGA Butterfly and Conservation Gardens (n=4) (USDA hardiness zone 8a, Spalding Co., GA).

Plant Type Number	Plant Common Name	Plant Scientific Name	All Pollinators Combined	All Beneficial Insects Combined
41	Ornamental Onion	*Allium senescens* 'Glaucum'	0.00 ± 0.00i	0.00 ± 0.00e
42	Smooth Aster 'Bluebird'	*Aster laevis* 'Bluebird'	0.02 ± 0.02hi	0.05 ± 0.03de
43	Tatarian Aster 'Jindai'	*Aster tataricus* 'Jindai'	0.00 ± 0.00i	0.00 ± 0.00e
44	Aster 'Professor Kippenburg'	*Aster novae-angliae* 'Professor Kippenburg'	0.02 ± 0.02hi	0.00 ± 0.00e
45	Blue Plumbago	*Ceratostigma plumbaginoides*	0.00 ± 0.00i	0.00 ± 0.00e
46	Coleus 'Mariposa Shades'	*Solenostemon scutellarioides* 'Mariposa Shades'	0.03 ± 0.02hi	0.03 ± 0.02de
47	Coreopsis 'Red Shift'	*Coreopsis auriculata* 'Red Shift'	0.59 ± 0.14bcdefg	0.29 ± 0.06abc
48	Coreopsis 'Snowberry'	*Coreopsis auriculata* 'Snowberry'	0.32 ± 0.11defghi	0.18 ± 0.06abcde
49	Coreopsis 'Cosmic Eye'	*Coreopsis* 'Cosmic Eye'	0.32 ± 0.11defghi	0.13 ± 0.06bcde
50	Dianthus 'Coconut Surprise'	*Dianthus hybrida* 'Coconut Surprise'	0.00 ± 0.00i	0.00 ± 0.00e
51	Dianthus 'Cheddar Pink'	*Dianthus gratianopolitanus* 'Cheddar Pink'	0.00 ± 0.00i	0.02 ± 0.02de
52	Foxglove 'Alba'	*Digitalis purpurea* 'Alba'	0.00 ± 0.00i	0.08 ± 0.05cde
53	Foxglove 'Excelsior Hybrid'	*Digitalis purpurea* 'Excelsior Hybrid'	0.00 ± 0.00i	0.00 ± 0.00e
54	White Snakeroot 'Chocolate'	*Eupatorium rugosum* 'Chocolate'	0.02 ± 0.02hi	0.00 ± 0.00e
55	Italian Parsley	*Petroselinum crispum*	0.00 ± 0.00i	0.03 ± 0.03de
56	Phlox 'Robert Poore'	*Phlox paniculata* 'Robert Poore'	0.02 ± 0.02hi	0.02 ± 0.02de
57	Blue Passion Flower	*Passiflora caerulea*	0.00 ± 0.00i	0.00 ± 0.00e
58	Mexican Petunia 'White Katie'	*Ruellia brittoniana* 'White Katie'	0.00 ± 0.00i	0.00 ± 0.00e
59	Sage 'Santa Barbara'	*Salvia leucantha* 'Santa Barbara'	0.00 ± 0.00i	0.00 ± 0.00e
60	Sweet Pepperbush	*Clethra alnifolia* 'Hummingbird'	0.00 ± 0.00i	0.07 ± 0.03de
61	Verbena 'Taylortown Red'	*Verbena canadensis* 'Taylortown Red'	0.15 ± 0.06fghi	0.05 ± 0.03de
62	Meadow Sage	*Salvia chiapensis*	0.00 ± 0.00i	0.00 ± 0.00e
63	Lamb's Ear	*Stachys byzantine*	0.02 ± 0.02hi	0.13 ± 0.06bcde
64	Virginia Sweetspire	*Itea virginica*	0.05 ± 0.03hi	0.00 ± 0.00e
65	Petunia Fuseables	*Petunia x hybrid*	0.02 ± 0.02hi	0.00 ± 0.00e
66	Black-Eyed Susan Vine	*Thunbergia alata*	0.00 ± 0.00i	0.00 ± 0.00e
67	Ornamental Tobacco	*Nicotiana alata*	0.00 ± 0.00i	0.00 ± 0.00e
68	Princess Flower	*Tibouchina urvilleana*	0.02 ± 0.02hi	0.00 ± 0.00e
69	Midnight Ginger	*Zingiber malayensis.*	0.00 ± 0.00i	0.00 ± 0.00e
70	Palm Grass	*Setaria palmifolia* 'Rubra Variegata'	0.00 ± 0.00i	0.00 ± 0.00e
71	Ornamental Corn 'Tiger Cub'	*Zea mays* 'Tiger Cub'	0.10 ± 0.04fghi	0.02 ± 0.02de
72	Sage 'Mystic Spires'	*Salvia* 'Mystic Spires'	0.38 ± 0.13cdefghi	0.00 ± 0.00e
73	Pineapple Sage	*Salvia elegans*	0.08 ± 0.04fghi	0.00 ± 0.00e
74	Trumpet Honeysuckle	*Lonicera sempervirens* 'Major Wheeler'	0.88 ± 0.30abc	0.22 ± 0.09abcd

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.2. Influence of plant type, observation date, and observation time on pollinator and beneficial insect taxa occurrence observed from June 4-September 5, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding Co., GA) (more information provided in Table A.1).

Insect Taxa	**Degrees of Freedom**			**P-Value**			**F-Value**		
	Plant Type	Date	Obs. Time	Plant Type	Date	Obs. Time	Plant Type	Date	Obs. Time
Bumble Bees	73, 4391	13, 4391	1, 4391	<0.0001***	0.0007***	0.0035**	13.14	2.76	8.51
Dolichopodidae	73, 4391	13, 4391	1, 4391	<0.0001***	0.0088**	0.2931	4.87	2.16	1.11
Hesperiidae	73, 4391	13, 4391	1, 4391	<0.0001***	0.0006***	0.0019**	2.63	2.76	9.61
Mordellidae	73, 4391	13, 4391	1, 4391	<0.0001***	<0.0001***	0.2309	8.74	3.62	1.44
Muscidae	73, 4391	13, 4391	1, 4391	<0.0001***	0.0221*	0.8711	3.32	1.94	0.03
Other Bees	73, 4391	13, 4391	1, 4391	<0.0001***	0.0001***	0.9909	3.73	3.10	0.00
Pieridae	73, 4391	13, 4391	1, 4391	<0.0001***	0.0692	0.1729	11.13	1.63	1.86
Small Bees	73, 4391	13, 4391	1, 4391	<0.0001***	<0.0001***	0.4859	6.00	6.18	0.49
Syrphidae	73, 4391	13, 4391	1, 4391	<0.0001***	<0.0001***	0.4695	2.89	3.71	0.52
Junonica coenia	73, 4391	13, 4391	1, 4391	<0.0001***	0.0374*	0.0419*	2.61	1.80	4.14
All Pollinators Combined	73, 4391	13, 4391	1, 4391	<0.0001***	<0.0001***	0.4944	8.44	3.81	0.47
Asilidae	73, 4391	13, 4391	1, 4391	<0.0001***	0.2074	0.4353	2.05	1.30	0.61
Cantharidae	73, 4391	13, 4391	1, 4391	<0.0001***	0.0024**	0.8745	3.92	2.47	0.02
Lampyridae	73, 4390	13, 4390	1, 4390	<0.0001***	<0.0001***	0.9894	4.37	3.63	0.00
Miridae	73, 4391	13, 4391	1, 4391	<0.0001***	0.0406*	0.0249*	8.74	3.62	1.44
Oecanthinae	73, 4391	13, 4391	1, 4391	<0.0001***	0.0012**	0.7638	3.97	2.63	0.09
Pentatomidae	73, 4390	13, 4390	1, 4390	<0.0001***	0.1075	0.9922	2.08	1.50	0.00
Geocoris punticpes	73, 4391	13, 4391	1, 4391	<0.0001***	0.0001***	0.2244	2.78	3.11	1.48
All Beneficial Insects Combined	73, 4389	13, 4389	1, 4389	<0.0001***	<0.0001***	0.7500	6.18	4.79	0.10

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

Table 4.3. Comparison for mean (± S.E.) of pollinating insect taxa observed through visual observations on seventy-four plant types over a fourteen-date period from June 4-September 5, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Bumble Bees	Dolichopodidae	Hesperiidae	Mordellidae	Muscidae	Other Bees	Pieridae	Small Bees	Syrphidae	*J. coenia*
1	0.13 ±0.04cdef	0.00 ±0.00c	0.02 ±0.02ab	0.00 ±0.00c	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.03 ±0.02def	0.02 ±0.02c	0.00 ±0.00c
2	**0.90 ±0.14a**	0.00 ±0.00c	**0.08 ±0.04a**	0.00 ±0.00c	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.02 ±0.02ef	0.05 ±0.03bc	0.08 ±0.04ab
3	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00b	0.20 ±0.10b	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.02 ±0.02ef	0.33 ±0.16ab	0.00 ±0.00c
4	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00c	0.00 ±0.00c	0.03 ±0.02b	0.00 ±0.00b	0.02 ±0.02ef	0.00 ±0.00c	0.00 ±0.00c
5	0.03 ±0.02ef	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00c	0.00 ±0.00c	0.02 ±0.02b	0.00 ±0.00b	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00c
6	0.00 ±0.00f	0.02 ±0.02bc	0.00 ±0.00b	0.07 ±0.05c	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00f	0.34 ±0.24ab	0.02 ±0.02bc
7	0.00 ±0.00f	0.07 ±0.03bc	0.00 ±0.00b	0.00 ±0.00c	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00c
8	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00c	0.00 ±0.00c	0.02 ±0.02b	0.00 ±0.00b	0.02 ±0.02ef	0.00 ±0.00c	0.00 ±0.00c
9	0.09 ±0.04def	0.00 ±0.00c	0.00 ±0.00b	0.02 ±0.02c	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00c
10	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00c	0.08 ±0.04ab	0.00 ±0.00b	**0.18 ±0.05a**	0.03±0.02def	0.27 ±0.08abc	0.05 ±0.03bc
11	0.05 ±0.04def	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00c	0.03 ±0.02bc	0.02 ±0.02b	0.00 ±0.00b	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00c
12	0.00 ±0.00f	0.03 ±0.03bc	0.00 ±0.00b	0.00 ±0.00c	0.02 ±0.02bc	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00c
13	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00c	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00c
14	0.07 ±0.03def	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00c	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.02 ±0.02ef	0.00 ±0.00c	0.00 ±0.00c
15	0.52 ±0.08b	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00c	0.00 ±0.00c	0.02 ±0.02b	0.00 ±0.00b	0.00 ±0.00f	0.21 ±0.12abc	0.00 ±0.00c
16	0.00 ±0.00f	0.07 ±0.03bc	0.00 ±0.00b	0.00 ±0.00c	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.10 ±0.04bcdef	0.00 ±0.00c	0.00 ±0.00c
17	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00c	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00c
18	0.21 ±0.05cdef	0.10 ±0.04b	0.00 ±0.00b	0.00 ±0.00c	0.02 ±0.02bc	0.00 ±0.00b	0.00 ±0.00b	0.05 ±0.03cdef	0.02 ±0.02c	0.00 ±0.00c
19	0.03 ±0.03ef	0.00 ±0.00c	0.00 ±0.00b	0.03 ±0.02c	0.05±0.03abc	0.05 ±0.03b	0.00 ±0.00b	0.00 ±0.00f	0.12±0.07abc	0.00 ±0.00c
20	0.03 ±0.02ef	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00c	0.00 ±0.00c	0.03 ±0.02b	0.00 ±0.00b	0.12±0.04abcde	0.00 ±0.00c	0.00 ±0.00c
21	0.23 ±0.12cdef	0.07 ±0.05bc	0.03 ±0.02ab	**0.41 ±0.10a**	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.03 ±0.02def	0.00 ±0.00c	0.00 ±0.00c
22	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00b	0.03 ±0.02c	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00f	0.00 ±0.00c	0.00 ±0.00c
23	0.03 ±0.02ef	0.08 ±0.04bc	0.00 ±0.00b	0.02 ±0.02c	0.02 ±0.02bc	0.02 ±0.02b	0.00 ±0.00b	0.05±0.03cdef	0.00 ±0.00c	0.00 ±0.00c
24	0.03 ±0.02ef	0.00 ±0.00c	0.00 ±0.00b	0.00 ±0.00c	0.03 ±0.02bc	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00f	0.00 ±0.00c	0.03 ±0.02bc
25	0.00 ±0.00f	0.02 ±0.02bc	**0.08 ±0.04a**	0.00 ±0.00c	0.03±0.02bc	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00f	0.02 ±0.02c	0.02 ±0.02bc

Table 4.3. (Continued). Comparison for mean (± S.E.) of pollinating insect taxa observed through visual observations on seventy-four plant types over a fourteen-date period from June 4-September 5, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Bumble Bees	Dolichopodidae	Hesperiidae	Mordellidae	Muscidae	Other Bees	Pieridae	Small Bees	Syrphidae	*J. coenia*
26	0.00 ± 0.00f	0.03 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00c	0.05 ± 0.03abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
27	0.27± 0.12cde	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ef	0.00 ± 0.00c	0.00 ± 0.00c
28	0.02 ± 0.02f	**0.22 ± 0.05a**	0.00 ± 0.00b	0.00 ± 0.00c	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.02 ± 0.02c	0.00 ± 0.00c
29	0.00 ± 0.00f	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
30	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.03 ± 0.02bc	0.03 ± 0.02b	0.00 ± 0.00b	0.03 ± 0.02def	0.00 ± 0.00c	0.00 ± 0.00c
31	0.02 ± 0.02f	0.03 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00c	0.02 ± 0.02bc	0.03 ± 0.02b	0.00 ± 0.00b	**0.22 ± 0.05a**	0.03 ± 0.02c	0.00 ± 0.00c
32	0.00 ± 0.00f	0.03 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00c	0.03 ± 0.02bc	**0.15 ± 0.05a**	0.00 ± 0.00b	0.19 ± 0.07ab	0.12 ± 0.07abc	0.00 ± 0.00c
33	0.00 ± 0.00f	0.00 ± 0.00c	0.02 ± 0.02ab	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
34	0.29 ± 0.09bcd	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.10 ± 0.05abc	0.00 ± 0.00c
35	0.03 ± 0.02ef	0.00 ± 0.00c	0.02 ± 0.02ab	0.00 ± 0.00c	0.02 ± 0.02bc	0.03 ± 0.02b	0.00 ± 0.00b	0.00 ± 0.00f	0.10 ± 0.04abc	0.02 ±0.02bc
36	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
37	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
38	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
39	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
40	0.51 ± 0.13b	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.25 ± 0.12abc	0.02 ±0.02bc
41	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
42	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.02 ± 0.02c	0.00 ± 0.00c
43	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
44	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ef	0.00 ± 0.00c	0.00 ± 0.00c
45	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
46	0.00 ± 0.00f	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ef	0.00 ± 0.00c	0.00 ± 0.00c
47	0.05 ± 0.03def	0.08 ± 0.05bc	0.07 ± 0.04ab	0.00 ± 0.00c	**0.12 ± 0.04a**	0.05 ± 0.03b	0.03 ± 0.02b	0.13 ± 0.04abcd	0.05 ± 0.03bc	0.00 ± 0.00c
48	0.02 ± 0.02f	0.00 ± 0.00c	0.03 ± 0.03ab	0.00 ± 0.00c	**0.12 ± 0.04a**	0.00 ± 0.00b	0.00 ± 0.00b	0.15 ± 0.06abc	0.00 ± 0.00c	0.00 ± 0.00c
49	0.02 ± 0.02f	0.00 ± 0.00c	0.05 ± 0.04ab	0.02 ± 0.02c	0.07 ± 0.03abc	0.03 ± 0.03b	0.00 ± 0.00b	0.13 ± 0.04abcd	0.00 ± 0.00c	0.00 ± 0.00c
50	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.3. (Continued). Comparison for mean (± S.E.) of pollinating insect taxa observed through visual observations on seventy-four plant types over a fourteen-date period from June 4-September 5, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Bumble Bees	Dolichopodidae	Hesperiidae	Mordellidae	Muscidae	Other Bees	Pieridae	Small Bees	Syrphidae	*J. coenia*
51	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
52	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
53	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
54	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
55	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
56	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.02± 0.02c	0.00 ± 0.00c
57	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
58	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
59	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
60	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
61	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.07 ± 0.03c	0.00 ± 0.00c	0.00 ± 0.00b	0.02 ± 0.02b	0.03 ± 0.02def	0.03 ± 0.02c	0.05 ± .05bc
62	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ef	0.00 ± 0.00c	0.00 ± 0.00c
63	0.02 ± 0.02f	0.00 ± 0.00c	0.00 ± 0.00b	0.02 ± 0.02c	0.00 ± 0.00c	0.02 ± 0.02b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
64	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.02 ± .02bc
65	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
66	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
67	0.00 ± 0.00f	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
68	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
69	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
70	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.00 ± 0.00c	0.00 ± 0.00c
71	0.00 ± 0.00f	0.08 ± 0.04bc	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ef	0.00 ± 0.00c	0.00 ± 0.00c
72	0.37 ± 0.13bc	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ef	0.00 ± 0.00c	0.00 ± 0.00c
73	0.02 ± 0.02f	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00f	0.07 ± 0.03bc	0.00 ± 0.00c
74	0.24 ± 0.10cdef	0.03 ± 0.02bc	0.05 ± 0.03ab	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ef	**0.39 ± 0.24a**	**0.14 ± 0.07a**

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.4. Comparison for mean (± S.E.) of beneficial insect taxa observed through visual observations on seventy-four plant types over a fourteen-date from June 4-September 5, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Asilidae	Cantharidae	Lampyridae	Miridae	Oecanthinae	Pentatomidae	*G. punctipes*
1	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
2	0.00 ±0.00b	**0.13 ±0.04a**	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.05 ±0.02abc
3	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.07 ±0.03abc
4	0.00 ±0.00b	0.03 ±0.02b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
5	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.03 ±0.02abc
6	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
7	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.03 ±0.02cd	0.02 ±0.02ab	0.00 ±0.00c
8	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.05 ±0.03bcd	0.02 ±0.02ab	0.02 ±0.02bc
9	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.04 ±0.02ab	0.00 ±0.00c
10	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.02 ±0.02cd	**0.07 ±0.03a**	0.05 ±0.03abc
11	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	**0.24 ±0.09a**	0.00 ±0.00c	0.09 ±0.04abc
12	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.02 ±0.02ab	0.05 ±0.00abc
13	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.03 ±0.02cd	0.00 ±0.00c	0.00 ±0.00c
14	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.18 ±0.06ab	0.00 ±0.00c	0.00 ±0.00c
15	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.02 ±0.00bc
16	0.00 ±0.00b	0.05 ±0.03b	0.00 ±0.00d	0.00 ±0.00c	0.02 ±0.02cd	0.07 ±0.04a	0.00 ±0.00c
17	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
18	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.02 ±0.02c	0.02 ±0.02cd	0.00 ±0.00c	0.00 ±0.00c
19	0.00 ±0.00b	0.03 ±0.02b	0.00 ±0.00d	**0.17 ±0.06a**	0.15 ±0.06abc	0.00 ±0.00c	0.03 ±0.00abc
20	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.02 ±0.02c	0.02 ±0.02cd	0.00 ±0.00c	0.05 ±0.03abc
21	0.00 ±0.00b	0.03 ±0.02b	**0.13 ±0.04a**	0.10 ±0.05ab	0.00 ±0.00d	0.00 ±0.00c	**0.13 ±0.05a**
22	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.02 ±0.02bc
23	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.12 ±0.04abcd	0.00 ±0.00c	0.00 ±0.00c
24	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.03 ±0.00cd	0.00 ±0.00c	0.00 ±0.00c
25	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.05 ±0.00bcd	0.00 ±0.00c	0.02 ±0.02bc

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.4. (Continued). Comparison for mean (± S.E.) of beneficial insect taxa observed through visual observations on seventy-four plant types over a fourteen-date period from June 4-September 5, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Asilidae	Cantharidae	Lampyridae	Miridae	Oecanthinae	Pentatomidae	*G. punctipes*
26	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
27	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.02 ±0.02bc
28	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.03 ±0.02bc	0.10±0.04bcd	0.02 ±0.02ab	0.07 ±0.03abc
29	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
30	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.10 ±0.00bcd	0.00 ±0.00c	0.00 ±0.00c
31	0.00 ±0.00b	0.00 ±0.00b	0.07 ±0.05bc	0.02 ±0.02c	0.05 ±0.03bcd	0.05 ±0.03ab	0.00 ±0.00c
32	0.00 ±0.00b	0.00 ±0.00b	0.03 ±0.02bcd	0.00 ±0.00c	0.10 ±0.06bcd	0.02 ±0.02ab	0.05 ±0.03abc
33	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.02 ±0.02c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
34	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.03 ±0.02bc	0.02 ±0.02cd	0.02 ±0.02ab	0.00 ±0.00c
35	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.03 ±0.02cd	0.00 ±0.00c	0.02 ±0.02bc
36	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
37	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
38	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.03 ±0.02abc
39	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
40	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.02 ±0.02cd	0.00 ±0.00c	0.03 ±0.02abc
41	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
42	0.00 ±0.00b	0.00 ±0.00b	0.02 ±0.02cd	0.00 ±0.00c	0.02 ±0.02cd	0.00 ±0.00c	0.02 ±0.00bc
43	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
44	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
45	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
46	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.03 ±0.02cd	0.00 ±0.00c	0.00 ±0.00c
47	0.00 ±0.00b	0.00 ±0.00b	0.08 ±0.04ab	0.05 ±0.03bc	0.08 ±0.04bcd	0.02 ±0.02ab	0.05 ±0.03abc
48	0.00 ±0.00b	0.00 ±0.00b	0.02 ±0.02cd	0.02 ±0.02c	0.05 ±0.03bcd	0.03 ±0.02ab	0.07 ±0.03abc
49	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.03 ±0.02bc	0.02 ±0.02cd	0.00 ±0.00c	0.08 ±0.04abc
50	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.4. (Continued). Comparison for mean (± S.E.) of beneficial insect taxa observed through visual observations on seventy-four plant types over a fourteen-date period from June 4-September 5, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Asilidae	Cantharidae	Lampyridae	Miridae	Oecanthinae	Pentatomidae	*G. punctipes*
51	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.02 ±0.02cd	0.00 ±0.00c	0.00 ±0.00c
52	0.00 ±0.00b	0.07 ±0.05ab	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.02 ±0.02bc
53	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
54	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
55	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.03 ±0.03abc
56	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.02 ±0.02cd	0.00 ±0.00c	0.00 ±0.00c
57	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
58	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
59	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
60	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.07 ±0.03bcd	0.00 ±0.00c	0.00 ±0.00c
61	0.00 ±0.00b	0.00 ±0.00b	0.02 ±0.02cd	0.00 ±0.00c	0.03 ±0.02cd	0.00 ±0.00c	0.00 ±0.00c
62	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
63	0.00 ±0.00b	**0.13 ±0.06a**	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
64	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
65	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
66	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
67	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
68	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
69	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
70	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
71	0.00 ±0.00b	0.02 ±0.02b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
72	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
73	0.00 ±0.00b	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00d	0.00 ±0.00c	0.00 ±0.00c
74	**0.03 ±0.02a**	0.00 ±0.00b	0.00 ±0.00d	0.00 ±0.00c	0.05 ±0.03bcd	0.03 ±0.02ab	0.10 ±0.05ab

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.5. List of plant type number, plant common name, and plant scientific name of plants observed from August 26-November 4, 2013 through visual observations and comparison for mean (± S.E.) of "All Pollinators Combined" occurrence observed on seventy-six plant types in the UGA Butterfly and Conservation Gardens (n=4) (USDA hardiness zone 8A, Spalding Co., GA).

Plant Type Number	Plant Common Name	Plant Scientific Name	All Pollinators Combined
1	Abelia 'Raspberry Perfusion'	*Abelia x grandiflora* 'Raspberry Profusion'	0.18 ± 0.08h
2	Anise Hyssop 'Black Adder'	*Agastache* 'Black Adder'	2.11 ± 0.39cdefgh
3	Aster 'Wood's Pink'	Aster dumosus 'Wood's Pink'	0.20 ± 0.13h
4	Astilbe 'Visions in Pink'	*Astilbe chinensis* 'Visions in Pink'	0.04 ± 0.04h
5	Bee Balm 'Raspberry Wine'	*Monarda didyma* 'Raspberry Wine'	0.41 ± 0.22gh
6	Belamcanda 'Blackberry Lily'	*Belamcanda chinensis* 'Blackberry Lily'	0.20 ± 0.20h
7	Black Stem Elephant Ear	*Colocasia esculenta*	0.51 ± 0.22fgh
8	Threadleaf Bluestar	*Amsonia hubrichtii*	0.02 ± 0.02h
9	Brazilian Verbena	*Verbena bonariensis*	0.17 ± 0.07h
10	Bronze Fennel	*Foeniculum vulgare*	0.09 ± 0.09h
11	Butterfly Bush	*Buddleia*	1.41 ± 0.35cdefgh
12	Butterfly Ginger Lily	*Hedichium coronarium*	0.35 ± 0.13h
13	Button Bush	*Cephalanthus occidentalis*	0.39 ± 0.16h
14	Cassia 'Wild Senna'	*Cassia herbecarpa* 'Wild Senna'	1.20 ± 0.43defgh
15	Catmint 'Walker's Low'	*Nepeta x faassenii*	1.57 ± 0.41cdefgh
16	**Celosia**	***Celosia spicata***	**5.21 ± 0.80a**
17	Chrysanthemum 'Cambodian Queen'	*Chrysanthemum dendranthema* 'Cambodian Queen'	1.44 ± 0.54cdefgh
18	**Coleus Fuseables**	***Solenostemon scutellariodes***	**4.61 ± 0.71ab**
19	Yarrow 'Coronation Gold'	*Achillea filipendulina* 'Coronation Gold'	0.09 ± 0.09h
20	False Sunflower 'Summer Sun'	*Heliopsis scabra* 'Summer Sun'	0.00 ± 0.00h
21	Gaura 'Passionate Blush'	*Gaura lindheimeri* 'Passionate Blush'	1.69 ± 0.49cdefgh
22	Hairy Loosestrife 'Firecracker'	*Lysimachia ciliata* 'Firecracker'	0.07 ± 0.05h
23	Joe Pye Weed 'Gateway'	*Eupatorium purpureum* 'Gateway'	0.51 ± 0.28fgh
24	Lantana 'Mozelle'	*Lantana camara* 'Mozelle'	2.72 ± 0.52bcdef
25	Lantana 'Ms. Huff'	*Lantana camara* 'Ms. Huff'	2.09 ± 0.53cdefgh
26	Lemon Balm	*Melissa officinalis*	1.07 ± 0.44efgh
27	Purple Coneflower 'Magnus'	*Echinacea purpurea* 'Magnus'	0.19 ± 0.09h
28	Queen Lily Ginger 'Emperor'	*Curcuma petiolata* 'Emperor'	0.42 ± 0.20gh
29	Red Leaf Hibiscus	*Hibiscus acetosella*	0.33 ± 0.17h
30	Rudbeckia 'Goldsturm'	*Rudbeckia fulgida* 'Goldsturm'	0.02 ± 0.02h
31	Rudbeckia 'Indian Summer'	*Rudbeckia hirta* 'Indian Summer'	0.31 ± 0.25h
32	Three-Lobed Coneflower	*Rudbeckia triloba*	0.00 ± 0.00h
33	Mexican Petunia 'Purple Showers'	*Ruellia brittoniana* 'Purple Showers'	0.59 ± 0.22fgh
34	Salvia 'Hot Lips'	*Salvia microphylla* 'Hot Lips'	3.44 ± 0.83abc
35	Yarrow 'Sunny Seduction'	*Achillea millefolium* 'Sunny Seduction'	0.00 ± 0.00h
36	Snowbush	*Breynia nivosa*	0.49 ± 0.36gh
37	Hummingbird Plant	*Dicliptera suberecta*	1.74 ± 0.42cdefgh
38	Lantana 'Pink Caprice'	*Lantana camara* 'Pink Caprice'	1.32 ± 0.59cdefgh

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.5 (Continued). List of plant type number, plant common name, and plant scientific name of plants observed from August 26-November 4, 2013 through visual observations and comparison for mean (± S.E.) of "All Pollinators Combined" occurrence observed on seventy-six plant types in the UGA Butterfly and Conservation Gardens (n=4) (USDA hardiness zone 8A, Spalding Co., GA).

Plant Type Number	Plant Common Name	Plant Scientific Name	All Pollinators Combined
39	Blue Beard 'First Choice'	*Caryopteris x clandonensis* 'First Choice'	0.29 ± 0.11h
40	Anise Hyssop 'Acapulco'	*Agastache mexicana 'Acapulco'*	2.87 ± 0.69bcde
41	Anise Hyssop 'Raspberry Nectar'	*Agastache* 'Raspberry Nectar'	1.82 ± 1.72cdefgh
42	Ornamental Onion	*Allium senescens* 'Glaucum'	0.47 ± 0.19gh
43	Smooth Aster 'Bluebird'	*Aster laevis* 'Bluebird'	2.64 ± 0.86bcdefg
44	Tatarian Aster 'Jindai'	*Aster tataricus* 'Jindai'	0.11 ± 0.11h
45	Aster 'Professor Kippenburg'	*Aster novae-angliae* 'Professor Kippenburg'	0.39 ± 0.16h
46	Bignonia 'Tangerine Beauty'	*Bignonia capreolata* 'Tangerine Beauty'	0.00 ± 0.00h
47	Blue Plumbago	*Ceratostigma plumbaginoides*	0.09 ± 0.05h
48	Coleus 'Mariposa Shades'	*Solenostemon scutellarioides* 'Mariposa Shades'	0.61 ± 0.23fgh
49	Coreopsis 'Red Shift'	*Coreopsis auriculata* 'Red Shift'	0.15 ± 0.12h
50	Coreopsis 'Snowberry'	*Coreopsis auriculata* 'Snowberry'	0.35 ± 0.16h
51	Coreopsis 'Cosmic Eye'	*Coreopsis* 'Cosmic Eye'	0.15 ± 0.11h
52	Dianthus 'Coconut Surprise'	*Dianthus hybrida* 'Coconut Surprise'	0.04 ± 0.04h
53	Dianthus 'Cheddar Pink'	*Dianthus gratianopolitanus* 'Cheddar Pink'	0.02 ± 0.02h
54	Foxglove 'Alba'	*Digitalis purpurea* 'Alba'	0.07 ± 0.05h
55	Foxglove 'Foxy'	*Digitalis purpurea* 'Foxy'	0.00 ± 0.00h
56	Foxglove 'Excelsior Hybrid'	*Digitalis purpurea* 'Excelsior Hybrid'	0.43 ± 0.43gh
57	White Snakeroot 'Chocolate'	*Eupatorium rugosum* 'Chocolate'	1.13 ± 0.45defgh
58	Italian Parsley	*Petroselinum crispum*	0.09 ± 0.06h
59	Phlox 'Robert Poore'	*Phlox paniculata* 'Robert Poore'	0.00 ± 0.00h
60	Blue Passion Flower	*Passiflora caerulea*	0.00 ± 0.00h
61	Mexican Petunia 'White Katie'	*Ruellia brittoniana* 'White Katie'	0.22 ± 0.13h
62	Sage 'Santa Barbara'	*Salvia leucantha* 'Santa Barbara'	0.27 ± 0.16h
63	Sage 'Wendy's Wish'	*Salvia hybrida* 'Wendy's Wish'	0.00 ± 0.00h
64	Verbena 'Taylortown Red'	*Verbena canadensis* 'Taylortown Red'	0.41 ± 0.22gh
65	Meadow Sage	*Salvia chiapensis*	1.20 ± 0.42defgh
66	Lamb's Ear	*Stachys byzantine*	0.57 ± 0.45fgh
67	Virginia Sweetspire	*Itea virginica*	0.04 ± 0.04h
68	Petunia Fuseables	*Petunia x hybrid*	0.45 ± 0.36gh
69	Black-Eyed Susan Vine	*Thunbergia alata*	2.17 ± 0.81cdefgh
70	Ornamental Tobacco	*Nicotiana alata*	0.00 ± 0.00h
71	Princess Flower	*Tibouchina urvilleana*	0.02 ± 0.02h
72	Midnight Ginger	*Zingiber malayensis.*	0.02 ± 0.02h
73	Palm Grass	*Setaria palmifolia* 'Rubra Variegata'	0.04 ± 0.03h
74	Ornamental Corn 'Tiger Cub'	*Zea mays* 'Tiger Cub'	0.00 ± 0.00h
75	Sage 'Mystic Spires'	*Salvia* 'Mystic Spires'	3.31 ± 0.87abcd
76	Trumpet Honeysuckle	*Lonicera sempervirens* 'Major Wheeler'	0.08 ± 0.08h

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.6. Influence of plant type and observation date on pollinator taxa occurrences observed during visual observations by Master Gardener volunteers from August 26-November 4, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding Co., GA) (more information provided in Table A.2).

Insect Taxa	Degrees of Freedom		P-Value		F-Value	
	Plant Type	Date	Plant Type	Date	Plant Type	Date
Bumble Bees	75, 3110	18, 3110	<0.0001***	0.0052**	6.61	2.06
Dolichopodidae	75, 3111	18, 3111	<0.0001***	<0.0001***	1.88	3.06
Hesperiidae	75, 3090	18, 3090	<0.0001***	0.0021**	5.07	2.23
Mordellidae	75, 3111	18, 3111	0.7505	0.9164	0.88	0.58
Muscidae	75, 3111	18, 3111	0.1621	0.1530	1.16	1.34
Other Bees	75, 3111	18, 3111	<0.0001***	<0.0001***	7.67	3.45
Pieridae	75, 3111	18, 3111	<0.0001***	<0.0001***	6.73	3.96
Small Bees	75, 3109	18, 3109	<0.0001***	0.0220*	4.28	1.78
Syrphidae	75, 3110	18, 3110	<0.0001***	<0.0001***	2.52	7.31
Vanessa spp.	75, 3111	18, 3111	0.0049**	0.3564	1.48	1.09
Papilio glaucus	75, 3111	18, 3111	<0.0001***	0.0964	1.81	1.46
Junonia coenia	75, 3111	18, 3111	<0.0001***	0.4554	2.10	1.00
All Pollinators Combined	75, 3086	18, 3086	<0.0001***	<0.0001***	10.22	3.43

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

Table 4.7. Comparison for mean (± S.E.) of pollinating insect taxa observed by Master Gardener volunteers through visual observations on seventy-six plant types over a nineteen-date period from August 26-November 4, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Bumble Bees	Dolichopodidae	Hesperiidae	Other Bees	Pieridae	Small Bees	Syrphidae	*Vanessa* spp.	*P. glaucus*	*J. coenia*
1	0.11 ± 0.07fg	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ±0.00d	0.02 ± 0.02b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.02 ± 0.02b	0.02 ± 0.02ab
2	0.93 ± 0.30bcde	0.04 ± 0.04a	0.20 ± 0.10cd	0.57 ±0.19bcd	0.07 ± 0.05b	0.24 ± 0.09bcd	0.07 ± 0.07abc	0.00 ± 0.00b	0.00 ±0.00b	0.02 ± 0.02ab
3	0.03 ± 0.03g	0.03 ± 0.03a	0.06 ± 0.06d	0.03 ± 0.03d	0.00 ± 0.00b	0.06 ± 0.06d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
4	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.04 ± 0.04abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
5	0.07 ± 0.05fg	0.11 ± 0.11a	0.13 ± 0.13cd	0.00 ± 0.00d	0.00 ± 0.00b	0.09 ± 0.09cd	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ab
6	0.00 ± 0.00g	0.13 ± 0.13a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.07 ± 0.07abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
7	0.00 ± 0.00g	0.40 ± 0.20a	0.00 ± 0.00d	0.07 ± 0.07cd	0.00 ± 0.00b	0.00 ± 0.00d	0.04 ± 0.04abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
8	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ab
9	0.00 ± 0.00g	0.00 ± 0.00a	0.02 ± 0.02d	0.02 ± 0.02d	0.02 ± 0.02b	0.07 ± 0.05d	0.00 ± 0.00c	0.00 ± 0.00b	0.02 ± 0.02b	0.02 ± 0.02ab
10	0.07 ± 0.07fg	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.03 ± 0.02ab	0.00 ± 0.00b	0.00 ± 0.00b
11	0.09 ± 0.07fg	0.00 ± 0.00a	0.72 ± 0.17abc	0.00 ± 0.00d	0.17 ± 0.09b	0.09 ± 0.09cd	0.02 ± 0.02bc	0.09 ± 0.05ab	**0.11 ± 0.06a**	0.13 ± 0.06ab
12	0.00 ± 0.00g	0.09 ± 0.07a	0.04 ± 0.03d	0.00 ± 0.00d	0.09 ± 0.05b	0.09 ± 0.07cd	0.00 ± 0.00c	0.02 ± 0.02b	0.00 ± 0.00b	0.00 ± 0.00b
13	0.00 ± 0.00g	0.07 ± 0.07a	0.15 ± 0.09cd	0.02 ± 0.02d	0.04 ± 0.04b	0.02 ± 0.02d	0.09 ± 0.09abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
14	0.35 ± 0.12defg	0.00 ± 0.00a	0.17 ± 0.11cd	0.09 ± 0.07cd	0.02 ± 0.02b	0.41 ± 0.23abcd	0.04 ± 0.04abc	0.00 ± 0.00b	0.00 ± 0.00b	0.07 ± 0.07ab
15	0.15 ± 0.08fg	0.11 ± 0.11a	0.72 ± 0.19abc	0.04 ± 0.04cd	0.11 ± 0.05b	0.43 ± 0.15abcd	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
16	1.19 ± 0.30abc	0.30 ± 0.11a	0.72 ± 0.20abc	0.98 ± 0.32ab	0.15 ± 0.07b	**1.21 ± 0.31a**	0.47 ± 0.18ab	0.00 ± 0.00b	0.00 ± 0.00b	**0.19 ± 0.08a**
17	0.04 ± 0.03g	0.37 ± 0.19a	0.22 ± 0.11bcd	0.02 ± 0.02d	0.04 ± 0.03b	0.36 ± 0.16bcd	0.33 ± 0.14abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
18	1.35 ± 0.35ab	0.52 ± 0.20a	0.04 ± 0.03d	**1.35 ± 0.35a**	0.11 ± 0.06b	1.00 ± 0.25ab	0.22 ± 0.12abc	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ab
19	0.00 ± 0.00g	0.07 ± 0.07a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
20	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
21	0.22 ± 0.13efg	0.28 ± 0.14a	0.09 ± 0.09cd	0.09 ± 0.06cd	0.07 ± 0.04b	0.46 ± 0.23abcd	**0.48 ± 0.20a**	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
22	0.00 ± 0.00g	0.02 ± 0.02a	0.02 ± 0.02d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
23	0.13 ± 0.11fg	0.00 ± 0.00a	0.22 ± 0.22bcd	0.04 ± 0.04cd	0.00 ± 0.00b	0.09 ± 0.04cd	0.00 ± 0.00c	0.00 ± 0.00b	0.02 ± 0.02b	0.00 ± 0.00b
24	0.30 ± 0.22defg	0.24 ± 0.19a	**1.00 ± 0.29a**	0.12 ± 0.12cd	0.15 ± 0.10b	0.15 ± 0.10cd	0.39 ± 0.19abc	0.09 ± 0.09ab	0.03 ± 0.03b	0.15 ± 0.10ab
25	0.00 ± 0.00g	0.52 ± 0.22a	0.54 ±0.15abcd	0.02 ± 0.02d	0.30 ± 0.12b	0.20 ± 0.08bcd	0.24 ± 0.12abc	0.07 ± 0.04ab	0.04±0.03ab	0.15 ± 0.07ab

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.7. (Continued). Comparison for mean (± S.E.) of pollinating insect taxa observed by Master Gardener volunteers through visual observations on seventy-six plant types over a nineteen-date period from August 26-November 4, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Bumble Bees	Dolichopodidae	Hesperiidae	Other Bees	Pieridae	Small Bees	Syrphidae	*Vanessa* spp.	*P. glaucus*	*J. coenia*
26	0.09 ± 0.07fg	0.33 ± 0.15a	0.38 ± 0.16abcd	0.00 ± 0.00d	0.07 ± 0.05b	0.09 ± 0.09cd	0.07 ± 0.07abc	0.00 ± 0.00b	0.02 ± 0.02b	0.04 ± 0.04ab
27	0.02 ± 0.02g	0.05 ± 0.03a	0.00 ± 0.00	0.03 ± 0.03d	0.00 ± 0.00b	0.03 ± 0.02d	0.00 ± 0.00c	0.02 ± 0.02b	0.00 ± 0.00b	0.00 ± 0.00b
28	0.02 ± 0.02g	0.15 ± 0.11a	0.07 ± 0.07d	0.00 ± 0.00d	0.02 ± 0.02b	0.00 ± 0.00d	0.13 ± 0.10abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
29	0.00 ± 0.00g	0.17 ± 0.12a	0.00 ± 0.00d	0.00 ± 0.00d	0.02 ± 0.02b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ab
30	0.00 ± 0.00g	0.00 ± 0.00a	0.02 ± 0.02d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
31	0.00 ± 0.00g	0.30 ± 0.22a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.02 ± 0.02d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ab
32	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
33	0.07 ± 0.05fg	0.15 ± 0.15a	0.11 ± 0.07cd	0.09 ± 0.09cd	0.09 ± 0.04b	0.04 ± 0.03d	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ab
34	0.74 ± 0.26bcdefg	0.20 ± 0.13a	0.13 ± 0.08cd	1.15 ± 0.33ab	0.24 ± 0.09b	0.98 ± 0.29ab	0.13 ± 0.09abc	0.02 ± 0.02b	0.00 ± 0.00b	0.04 ± 0.03ab
35	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
36	0.02 ± 0.02g	0.04 ± 0.04a	0.16 ± 0.10cd	0.02 ± 0.02d	0.02 ± 0.02b	0.16 ± 0.16cd	0.07 ± 0.07abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
37	0.04 ± 0.04g	0.00 ± 0.00a	0.46 ± 0.19abcd	0.00 ± 0.00d	**1.17 ± 0.33a**	0.07 ± 0.07d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
38	0.00 ± 0.00g	0.04 ± 0.04a	0.86 ± 0.50ab	0.00 ± 0.00d	0.17 ± 0.17b	0.04 ± 0.04d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.13 ± 0.07ab
39	0.03 ± 0.03g	0.00 ± 0.00a	0.03 ± 0.03d	0.09 ± 0.06cd	0.00 ± 0.00b	0.11 ± 0.09cd	0.03 ± 0.03abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
40	1.07 ± 0.29abcd	0.09 ± 0.09a	0.46 ± 0.17abcd	0.70 ± 0.26abc	0.04 ± 0.04b	0.48 ± 0.17abcd	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.04 ± 0.04ab
41	**1.82 ±1.72a**	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
42	0.04 ± 0.04g	0.15 ± 0.11a	0.04 ± 0.04d	0.00 ± 0.00d	0.04 ± 0.03b	0.09 ± 0.06cd	0.04 ± 0.04abc	0.00 ± 0.00b	0.00 ± 0.00b	0.04 ± 0.04ab
43	0.49 ± 0.23cdefg	0.09 ± 0.07a	0.72 ± 0.30abc	0.11 ± 0.06cd	0.04 ± 0.03b	0.89 ± 0.31abc	0.19 ± 0.12abc	0.04 ± 0.04ab	0.00 ± 0.00b	0.06 ± 0.06ab
44	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.11 ± 0.11abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
45	0.00 ± 0.00g	0.02 ± 0.02a	0.04 ± 0.03d	0.02 ± 0.02d	0.00 ± 0.00b	0.26 ± 0.11bcd	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00b	0.02 ± 0.02ab
46	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
47	0.00 ± 0.00g	0.07 ± 0.07a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.04 ± 0.04b	0.02 ± 0.02d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b
48	0.15 ± 0.10fg	0.09 ± 0.09a	0.00 ± 0.00d	0.11 ± 0.08cd	0.00 ± 0.00b	0.02 ± 0.02b	0.16 ± 0.13cd	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00b
49	0.00 ± 0.00g	0.09 ± 0.09a	0.04 ± 0.04d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00d	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00b
50	0.00 ± 0.00g	0.09 ± 0.09a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00b	0.22 ±0.13bcd	0.04 ± 0.04abc	0.00 ± 0.00b	0.00 ± 0.00b

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.7. (Continued). Comparison for mean (± S.E.) of pollinating insect taxa observed by Master Gardener volunteers through visual observations on seventy-six plant types over a nineteen-date period from August 26-November 4, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Bumble Bees	Dolichopodidae	Hesperiidae	Other Bees	Pieridae	Small Bees	Syrphidae	*Vanessa* spp.	*P. glaucus*	*J. coenia*
51	0.00 ± 0.00g	0.09 ± 0.09a	0.07 ± 0.07d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
52	0.04 ± 0.04g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
53	0.02 ± 0.02g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
54	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.02 ± 0.02b	0.00 ± 0.00d	0.02 ± 0.02bc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
55	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
56	0.14 ± 0.14fg	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.29 ± 0.29bcd	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
57	0.06 ± 0.04fg	0.35 ± 0.17a	0.20 ± 0.11cd	0.00 ± 0.00d	0.02 ± 0.02b	0.07 ± 0.07d	0.37 ± 0.21abc	0.02 ± 0.02b	0.00 ± 0.00b	0.04 ±0.04ab
58	0.00 ± 0.00g	0.00 ± 0.00a	0.06 ± 0.06d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.03 ± 0.03b	0.00 ± 0.00b
59	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
60	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
61	0.00 ± 0.00g	0.11 ± 0.08a	0.00 ± 0.00d	0.00 ± 0.00d	0.11 ± 0.11b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
62	0.00 ± 0.00g	0.04 ± 0.04a	0.00 ± 0.00d	0.00 ± 0.00d	0.17 ± 0.14b	0.00 ± 0.00d	0.00 ± 0.00c	0.04 ±0.04ab	0.00 ± 0.00b	0.00 ± 0.00b
63	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
64	0.00 ± 0.00g	0.22 ± 0.14a	0.02 ± 0.02d	0.00 ± 0.00d	0.04 ± 0.03b	0.00 ± 0.00d	0.11 ± 0.11abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
65	0.28 ± 0.19efg	0.00 ± 0.00a	0.04 ± 0.04d	0.50 ± 0.28bcd	0.09 ± 0.09b	0.26 ± 0.12bcd	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
66	0.83 ± 0.34bdef	0.09 ± 0.09a	0.23 ± 0.13bcd	1.14 ± 0.40ab	0.20 ± 0.10b	0.00 ± 0.00d	0.14 ± 0.10abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
67	0.00 ± 0.00g	0.09 ± 0.09a	0.00 ± 0.00d	0.00 ± 0.00d	0.13 ± 0.13b	0.22 ± 0.22bcd	0.00 ± 0.00c	**0.13 ± 0.13a**	0.00 ± 0.00b	0.00 ± 0.00b
68	0.00 ± 0.00g	0.04 ± 0.04a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
69	0.00 ± 0.00g	0.02 ± 0.02a	0.02 ± 0.02d	0.00 ± 0.00d	0.05 ± 0.03b	0.35 ± 0.35bcd	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
70	0.04 ± 0.04g	0.26 ± 0.26a	0.61 ± 0.27abcd	0.00 ± 0.00d	0.87 ± 0.37a	0.26 ± 0.26bcd	0.13 ± 0.13abc	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
71	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
72	0.00 ± 0.00g	0.00 ± 0.00a	0.02 ± 0.02d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
73	0.02 ± 0.02g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
74	0.00 ± 0.00g	0.02 ± 0.02a	0.00 ± 0.00d	0.00 ± 0.00d	0.02 ± 0.02b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
75	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
76	0.00 ± 0.00g	0.00 ± 0.00a	0.00 ± 0.00d	0.00 ± 0.00d	0.00 ± 0.00b	0.00 ± 0.00d	0.00 ± 0.00c	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.8. Influence of pan trap sampling date and pan trap type on pollinating, beneficial, and plant-feeding insect taxa collected over June 20-25, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding Co., GA) (more information provided Table A.3).

Insect Taxa	**Degrees of Freedom**		**P-Value**		**F-Value**	
	Date	Trap Type	Date	Trap Type	Date	Trap Type
Apidae	2, 136	13, 136	0.0024**	0.0787	6.37	1.66
Cephidae	2, 136	13, 136	0.6701	0.0009***	0.02	2.98
Chalcidoidea	2, 136	13, 136	0.0791	<0.0001***	2.59	4.50
Chironomidae	2, 136	13, 136	0.0104**	0.6845	4.75	0.78
Dolichopodidae	2, 136	13, 136	0.1026	<0.0001***	2.32	7.56
Hesperiidae	2, 136	13, 136	0.1356	0.0011**	1.66	2.91
Mordellidae	2, 136	13, 136	0.0070**	<0.0001***	5.17	4.21
Other Flies	2, 136	13, 136	0.0041**	0.0054**	5.77	2.46
Small Bees	2, 135	13, 135	0.0028**	<0.0001***	6.18	3.92
Syrphidae	2, 136	13, 136	0.0378*	<0.0001***	3.37	3.95
Tephritidae	2, 136	13, 136	0.6798	0.0013**	0.39	2.87
All Pollinators Combined	2, 135	13, 135	0.0003***	<0.0001***	8.63	13.18
Asilidae	2, 136	13, 136	0.0913	0.3747	0.99	1.61
Carabidae	2, 136	13, 136	0.4522	0.0275*	0.79	1.99
Formicidae	2, 136	13, 136	0.0110*	0.0027**	4.69	2.66
Lampyridae	2, 136	13, 136	0.4338	0.0091**	0.84	2.31
Staphylinidae	2, 136	13, 136	0.4484	0.0074**	0.81	2.37
All Beneficial Insects Combined	2, 136	13, 136	0.7743	<0.0001***	0.26	3.64
Curculionidae	2, 136	13, 136	0.0919	0.0419*	2.44	1.86
Cicadellidae	2, 136	13, 136	<0.0001***	<0.0001***	11.83	30.95
Aphididae	2, 136	13, 136	0.0349*	<0.0001***	3.45	6.80
Cercopoidea	2, 136	13, 136	0.1000	0.0002***	2.35	3.42
Plataspidae	2, 136	13, 136	0.0202*	0.4783	4.03	0.98
Thripidae	2, 136	13, 136	0.0383*	0.4135	3.35	1.05
All Plant-Feeding Insects Combined	2, 136	13, 136	<0.0001***	<0.0001***	14.43	22.40

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

Table 4.9. Comparison for mean (± S.E.) of pollinating, beneficial, and plant-feeding insect taxa collected from fourteen trap types over June 20-25, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding Co., GA).

	Date		
Insect Taxa	21 June	23 June	25 June
Apidae	0.00 ± 0.00b	**0.25 ± 0.08a**	0.06 ± 0.03b
Chironomidae	**0.07 ± 0.05a**	0.00 ± 0.00b	0.00 ± 0.00b
Mordellidae	0.15 ± 0.07b	**3.67 ± 1.33a**	1.17 ± 0.42ab
Other Flies	0.09 ± 0.05b	**0.61 ± 0.12a**	0.58 ± 0.13a
Small Bees	0.67 ± 0.17b	**2.67 ± 0.72a**	0.98 ± 0.21b
Syrphidae	**0.29 ± 0.12a**	**0.27 ± 0.10a**	0.06 ± 0.03b
All Pollinators Combined	2.70 ± 0.71b	**16.3 ± 4.53a**	8.56 ± 2.27b
Formicidae	0.26 ± 0.09b	0.82 ± 0.20ab	**1.17 ± 0.26a**
All Beneficial Insects Combined	1.97 ± 0.55a	2.08 ± 0.34a	2.33 ± 0.37a
Cicadellidae	0.12 ± 0.09b	**2.43 ± 0.78a**	**1.98 ± 0.62a**
Aphididae	0.03 ± 0.03b	**0.39 ± 0.14a**	0.35 ± 0.13ab
Plataspidae	0.00 ± 0.00a	0.08 ± 0.04a	0.00 ± 0.00a
Thripidae	0.98 ± 0.34ab	**0.44 ± 0.32a**	0.10 ± 0.05b
All Plant-Feeding Insects Combined	1.32 ± 0.44c	**4.90 ± 0.96a**	2.94 ± 0.72b

Means in the same row bearing different letters are significantly different (α=0.05).

Table 4.10. Reference key in which each trap type number corresponds to a particular trap type (trap color, trap shape, trap height).

Trap Type Number	Trap Type
1	Red, Cup, Stand
2	Violet, Cup, Ground
3	Blue, Bowl, Stand
4	Yellow, Cup, Stand
5	Yellow, Bowl, Ground
6	Red, Bowl, Stand
7	Red, Bowl, Ground
8	Blue, Cup, Ground
9	Yellow, Cup, Ground
10	Blue, Bowl, Ground
11	Blue, Cup, Stand
12	Red, Cup, Ground
13	Yellow, Bowl, Stand
14	Violet, Cup, Stand

Table 4.11. Comparison for mean (± S.E.) of pollinating, beneficial, and plant-feeding insect taxa collected from 14 trap types over June 20-25, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding Co., GA).

	Pan Trap Type Number						
Insect Taxa	1	2	3	4	5	6	7
Cephidae	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	**0.25 ± 0.16a**	0.00 ± 0.00b	0.00 ± 0.00b
Chalcidoidea	0.00 ± 0.00b	0.18 ± 0.18b	0.00 ± 0.00b	0.10 ± 0.10b	**1.86 ± 0.77a**	0.09 ± 0.09b	0.36 ± 0.28b
Dolichopodidae	0.00 ± 0.00b	0.09 ± 0.09b	0.25 ± 0.16b	4.20 ± 1.55b	**33.9 ± 13.3a**	0.27 ± 0.14b	1.09 ± 0.56b
Hesperiidae	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
Moredellidae	0.28 ± 0.18c	1.00 ± 0.63bc	0.25 ± 0.16c	0.70 ± 0.26c	**13.1 ± 6.68a**	0.27 ± 0.19c	0.45 ± 0.25c
Other Flies	0.29 ± 0.18ab	0.18 ± 0.12ab	1.00 ± 0.38ab	0.10 ± 0.10ab	**1.25 ± 0.41a**	0.45 ± 0.31ab	0.72 ± 0.27ab
Small Bees	0.50 ± 0.34c	0.55 ± 0.21c	3.00 ± 1.21abc	0.60 ± 0.33c	**5.38 ± 1.69a**	0.18 ± 0.12c	0.27 ± 0.19c
Syrphidae	0.00 ± 0.00b	0.27 ± 0.14b	0.25 ± 0.16b	0.00 ± 0.00b	**1.25 ± 0.45a**	0.00 ± 0.00b	0.00 ± 0.00b
Tephritidae	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	**0.25 ± 0.16a**	0.00 ± 0.00b	0.00 ± 0.00b
All Pollinators Combined	1.50 ± 0.34b	2.45 ± 0.71b	5.25 ± 1.36b	7.20 ± 1.95b	**72.5 ± 19.1a**	1.72 ± 0.51b	3.82 ± 0.97b
Carabidae	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
Formicidae	0.14 ± 0.14a	1.00 ± 0.54a	0.25 ± 0.16a	0.10 ± 0.10a	1.75 ± 0.75a	0.09 ± 0.09a	1.27 ± 0.47a
Lampyridae	0.14 ± 0.14a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a
Staphylinidae	0.29 ± 0.18b	0.72 ± 0.38ab	0.38 ± 0.18b	0.40 ± 0.22b	1.00 ± 0.53ab	0.55 ± 0.21ab	0.72 ± 0.27ab
All Beneficial Insects Combined	0.57 ± 0.30c	2.45 ± 0.81abc	0.75 ± 0.25bc	0.60 ± 0.22c	4.38 ± 1.22ab	1.36 ± 0.45abc	0.81 ± 0.26abc
Curculionidae	0.00 ± 0.00b	0.09 ± 0.09b	**1.13 ± 0.85a**	0.00 ± 0.00b	0.13 ± 0.13b	0.00 ± 0.00b	0.00 ± 0.00b
Cicadellidae	0.00 ± 0.00c	0.00 ± 0.00c	0.00 ± 0.00c	1.00 ± 0.52c	**15.4 ± 2.43a**	0.00 ± 0.00c	0.36 ± 0.20c
Aphididae	0.14± 0.14b	0.00 ± 0.00b	0.12 ± 0.12b	0.30 ± 0.15b	**2.00 ± 0.65a**	0.09 ± 0.09b	0.09 ± 0.09b
Cercopoidea	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	**0.62 ± 0.32a**	0.00 ± 0.00b	0.00 ± 0.00b
All Plant-Feeding Insects Combined	1.00 ± 0.44c	1.18 ± 0.81c	3.25 ± 1.28c	1.90 ± 0.66c	**19.3 ± 2.82a**	1.18± 0.30c	0.82 ± 0.26c

Means in the same row bearing different letters are significantly different (α=0.05).

Table 4.11. (Continued). Comparison for mean (± S.E.) of pollinating, beneficial, and plant-feeding insect taxa collected from 14 trap types over June 20-25, 2013 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding Co., GA).

	Pan Trap Type Number						
Insect Taxa	8	9	10	11	12	13	14
Cephidae	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
Chalcidoidea	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.10 ± 0.10b	0.00 ± 0.00b	0.50 ± 0.27b	0.00 ± 0.00b
Dolichopodidae	0.00 ± 0.00b	3.28 ± 1.09b	0.09 ± 0.09b	0.00 ± 0.00b	0.70 ± 0.50b	9.13 ± 2.75b	0.09 ± 0.09b
Hesperiidae	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	**0.25 ± 0.16a**	0.00 ± 0.00b
Mordellidae	0.50 ± 0.31c	1.18 ± 0.38bc	1.18 ± 0.90bc	0.50 ± 0.22c	0.80 ± 0.39c	**9.25 ± 4.11a**	0.00 ± 0.00c
Other Flies	0.90 ± 0.38ab	0.55 ± 0.28ab	0.64± 0.24ab	0.00 ± 0.00b	0.50 ± 0.22ab	0.13 ± 0.13ab	0.00 ± 0.00b
Small Bees	1.50 ± 0.50bc	1.09 ± 0.39bc	1.09 ± 0.37bc	1.20 ± 0.29bc	1.00 ± 0.39bc	**7.13 ± 3.65a**	0.36 ± 0.28c
Syrphidae	0.30 ± 0.15b	0.09 ± 0.09b	0.27 ± 0.27b	0.30 ± 0.21b	0.00 ± 0.00b	0.13 ± 0.13b	0.09 ± 0.09b
Tephritidae	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
All Pollinators Combined	3.80 ± 0.9b	8.45 ± 1.62b	4.82 ± 1.26b	2.60 ± 0.31b	7.10 ± 3.70b	35.3 ± 10.7b	1.18 ± 0.35b
Carabidae	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	**0.25 ± 0.16a**	0.09 ± 0.09ab
Formicidae	1.40 ± 0.45a	0.63 ± 0.31a	2.00 ± 0.81a	0.30 ± 0.21a	1.70 ± 0.65a	0.00 ± 0.00a	0.45 ± 0.28a
Lampyridae	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	**0.25 ± 0.16a**	0.00 ± 0.00b
Staphylinidae	0.20 ± 0.20b	**3.00 ± 1.46a**	1.18 ± 0.44ab	0.10 ± 0.10b	0.20 ± 0.20b	0.13 ± 0.13b	0.00 ± 0.00b
All Beneficial Insects Combined	2.20 ± 0.87abc	**4.72 ± 1.48a**	4.18 ± 1.05abc	1.20 ± 0.40abc	2.40 ± 0.62abc	1.13 ± 0.35abc	0.55 ± 0.28c
Curculionidae	0.00 ± 0.00b	0.00 ± 0.00b	0.45 ± 0.21a	0.10 ± 0.10b	0.10 ± 0.10b	0.13 ± 0.13b	0.09 ± 0.09b
Cicadellidae	0.50 ± 0.31c	1.55 ± 0.45c	0.36 ± 0.15c	0.10 ± 0.10c	0.10 ± 0.10c	8.25 ± 1.93b	0.00 ± 0.00c
Aphididae	0.10± 0.10b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.20 ± 0.13b	**1.50 ± 0.63a**	0.09 ± 0.09b
Cercopoidea	0.00 ± 0.00b	0.18 ± 0.12b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.13 ± 0.13b	0.00 ± 0.00b
All Plant-Feeding Insects Combined	3.00 ± 1.41c	3.27 ± 1.07c	2.45 ± 0.62c	0.80 ± 0.39c	0.70 ± 0.30c	10.8 ± 2.09b	1.18 ± 0.40c

Means in the same row bearing different letters are significantly different (α=0.05).

Table 4.12. Influence of pan trap sampling date on occurrences on pollinating, beneficial, and plant-feeding taxa collected over a seven-date period from June 24-August 4, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding Co., GA) (more information provided in Table A.4).

	Pan Trap Sampling Date		
Insect Taxa	Degrees of Freedom	P-Value	F-Value
Chironomidae	6,55	0.0065**	3.48
Dolichopodidae	6,55	<0.0001***	6.33
Mordellidae	6,55	0.0093**	3.27
Other Flies	6,55	0.0327*	2.55
Small Bees	6,55	<0.0001***	7.12
Syrphidae	6,55	0.0048**	3.66
All Pollinators Combined	6,55	<0.0001***	6.38
Braconidae	6,55	0.0458*	2.36
Oecanthinae	6,55	0.0224*	2.77
All Beneficial Insects Combined	6,55	0.0176*	2.91
Cicadellidae	6,55	0.0002***	4.55
Aphididae	6,55	0.0002***	5.74
Thripidae	6,55	0.0102*	3.22
All Plant-Feeding Insects Combined	6,55	0.0001***	6.00

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

Table 4.13. Comparison for mean (± S.E.) of pollinating, beneficial, and plant-feeding insect taxa collected in the UGA Butterfly and Conservation Gardens(Spalding Co., GA) (n=4) through pan trapping over a seven-date period from June 24-August 4, 2014.

	Pan Trap Sampling Date						
Insect Taxa	June 24	July 1	July 8	July 15	July 22	July 28	August 4
Chironomidae	0.88 ± 0.40b	3.63 ± 1.07ab	1.63 ± 0.80ab	**4.88 ± 1.09a**	1.63 ± 0.42ab	2.00 ± 0.50ab	1.38 ± 0.63b
Dolichopodidae	20.0 ± 6.10c	43.5 ± 7.03ab	16.0 ± 6.85c	**45.8 ± 7.73a**	26.0 ± 4.43abc	21.1 ± 5.32bc	11.4 ± 4.60c
Mordellidae	0.38 ± 0.26ab	0.50 ± 0.38ab	0.25 ± 0.25b	**1.63 ± 0.77a**	0.13 ± 0.13b	0.13 ± 0.13b	0.00 ± 0.00b
Other Flies	1.38 ± 0.65a	0.00 ± 0.00a	0.00 ± 0.00a	0.25 ± 0.25a	0.00 ± 0.00a	0.88 ± 0.44a	0.38 ± 0.18a
Small Bees	3.75 ± 1.18b	4.38 ± 0.56b	1.63 ± 0.73b	**5.13 ± 0.69a**	**9.00 ± 1.52a**	3.25 ± 0.80b	1.63 ± 0.68b
Syrphidae	1.63 ± 0.86ab	**1.75 ± 0.56a**	0.50 ± 0.27ab	0.75 ± 0.41ab	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
All Pollinators Combined	31.1 ± 7.46bc	55.5 ± 8.15ab	21.6 ± 8.91c	**60.6 ± 7.81a**	38.8 ± 4.72abc	30.8 ± 6.03bc	17.1 ± 6.31c
Braconidae	0.13 ± 0.13ab	**0.75 ± 0.25a**	0.13 ± 0.13ab	0.25 ± 0.25ab	0.00 ± 0.00b	0.00 ± 0.00b	0.25 ± 0.16ab
Oecanthinae	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.13 ± 0.13ab	0.00 ± 0.00b	**0.75 ± 0.41a**	0.00 ± 0.00b
All Beneficial Insects Combined	2.63 ± 0.99ab	**4.88 ± 1.09a**	1.13 ± 0.61ab	3.25 ± 1.06ab	0.88 ± 0.40b	4.00 ± 0.82ab	2.00 ± 0.80ab
Cicadellidae	15.0 ± 4.53a	**16.0 ± 2.59a**	4.38 ± 1.95b	12.8 ± 1.70ab	5.13 ± 1.41b	8.25 ± 1.54ab	3.25 ± 1.46b
Aphididae	0.13 ± 0.13b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.25 ± 0.16b	**1.13 ± 0.40a**
Thripidae	**1.75 ± 0.70a**	1.25 ± 0.49ab	0.25 ± 0.16ab	0.38 ± 0.18ab	0.13 ± 0.13b	1.00 ± 0.33ab	0.00 ± 0.00b
All Plant-Feeding Insects Combined	**17.4 ± 4.23a**	**17.3 ± 2.51a**	4.88± 2.17b	14.6 ± 1.79ab	5.63 ± 1.57b	10.4 ± 2.18ab	5.13 ± 1.76b

Means in the same row bearing different letters are significantly different (α=0.05).

Table 4.14. Number of each species of bee taxa collected at each pan trap sampling date in the UGA Butterfly and Conservation Gardens (Spalding Co., GA) (n=4) and total number of each species collected in Summer 2013 and 2014 pan trap samples.

Bee Species	**Number of Bees Collected** **Date** 20-25 June 2013	24 June 2014	1 July 2014	8 July 2014	15 July 2014	22 July 2014	28 July 2014	4 August 2014	**Total**
Agapostemon virescens	0	0	0	0	2	0	1	0	3
Augochlora pura pura	0	0	0	0	1	1	1	0	3
Bombus griseocollis	2	0	0	0	1	0	0	0	3
Bombus impatiens	2	0	0	0	0	0	0	0	2
Halictus ligatus	**34**	4	3	0	1	7	2	3	**54**
Halictus parrallelus	2	0	0	0	0	0	0	0	2
Holcopasites calliopsidis	0	0	1	0	0	0	0	0	1
Lasioglossum (dialictus) coreopsis	1	0	0	0	0	0	0	0	1
Lasioglossum (dialictus) disparile	9	1	1	0	0	1	1	0	13
Lasioglossum (dialictus) illnoensis	1	0	0	0	1	0	0	0	2
Lasioglossum (dialictus) imitatum	1	7	21	8	19	**33**	20	7	**116**
Lasioglossum (dialictus) mitchelli	1	0	0	0	0	0	0	0	1
Lasioglossum (dialictus) tegulare	1	0	0	0	0	0	0	0	1
Lasioglossum (hemihalictus) lustrans	0	3	0	0	0	0	0	0	3
Melissodes comptoides	8	0	0	0	0	0	0	0	8
Ptilothrix bombiformis	1	0	0	0	0	0	0	0	1

Table 4.15. Number of each species of bee taxa collected by each of the fourteen pan trap types in the UGA Butterfly and Conservation Gardens (Spalding Co., GA) (n=4) and total number of each species collected in Summer 2013 and 2014 pan trap samples.

Bee Species	**Number of Bees Collected Trap Type**														**Total**
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Agapostemon virescens	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3
Augochlora pura pura	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3
Bombus griseocollis	2	0	0	0	1	0	0	0	2	0	0	0	0	0	3
Bombus impatiens	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Halictus ligatus	**0**	0	0	4	**40**	0	0	0	3	0	0	0	7	0	**54**
Halictus parrallelus	2	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Holcopasites calliopsidis	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Lasioglossum (dialictus) coreopsis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Lasioglossum (dialictus) disparile	0	0	0	1	9	0	0	0	1	0	0	0	2	0	13
Lasioglossum (dialictus) illnoensis	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Lasioglossum (dialictus) imitatum	0	0	0	0	**115**	0	0	0	1	0	0	0	0	0	**116**
Lasioglossum (dialictus) mitchelli	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Lasioglossum (dialictus) tegulare	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Lasioglossum (hemihalictus) lustrans	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3
Melissodes comptoides	0	0	0	0	3	0	0	0	0	1	0	0	4	0	8
Ptilothrix bombiformis	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1

Table 4.16. List of plant type number, plant common name, and plant scientific name of plant taxa sampled by sweep-netting over a seven-date period from June 10-July 22, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (USDA hardiness zone 8A, Spalding Co., GA).

Plant Type Number	Plant Common Name	Plant Scientific Name
1	Abelia 'Raspberry Perfusion'	*Abelia x grandiflora* 'Raspberry Profusion'
2	Anise Hyssop 'Black Adder'	*Agastache* 'Black Adder'
3	Aster 'Wood's Pink'	Aster dumosus 'Wood's Pink'
4	Astilbe 'Visions in Pink'	*Astilbe chinensis* 'Visions in Pink'
5	Bee Balm 'Raspberry Wine'	*Monarda didyma* 'Raspberry Wine'
6	Belamcanda 'Blackberry Lily'	*Belamcanda chinensis* 'Blackberry Lily'
7	Black Stem Elephant Ear	*Colocasia esculenta*
8	Threadleaf Bluestar	*Amsonia hubrichtii*
9	Brazilian Verbena	*Verbena bonariensis*
10	Bronze Fennel	*Foeniculum vulgare*
11	Butterfly Bush	*Buddleia*
12	Butterfly Ginger Lily	*Hedichium coronarium*
13	Button Bush	*Cephalanthus occidentalis*
14	Cassia 'Wild Senna'	*Cassia herbecarpa* 'Wild Senna'
15	Catmint 'Walker's Low'	*Nepeta x faassenii*
16	Celosia	*Celosia spicata*
17	Chrysanthemum 'Cambodian Queen'	*Chrysanthemum dendranthema* 'Cambodian Queen'
18	Coleus Fuseables	*Solenostemon scutellariodes*
19	Yarrow 'Coronation Gold'	*Achillea filipendulina* 'Coronation Gold'
20	False Sunflower 'Summer Sun'	*Heliopsis scabra* 'Summer Sun'
21	Gaura 'Passionate Blush'	*Gaura lindheimeri* 'Passionate Blush'
22	Hairy Loosestrife 'Firecracker'	*Lysimachia ciliata* 'Firecracker'
23	Joe Pye Weed 'Gateway'	*Eupatorium purpureum* 'Gateway'
24	Lantana 'Mozelle'	*Lantana camara* 'Mozelle'
25	Lantana 'Ms. Huff'	*Lantana camara* 'Ms. Huff'
26	Lemon Balm	*Melissa officinalis*
27	Purple Coneflower 'Magnus'	*Echinacea purpurea* 'Magnus'
28	Queen Lily Ginger 'Emperor'	*Curcuma petiolata* 'Emperor'
29	Red Leaf Hibiscus	*Hibiscus acetosella*
30	Rudbeckia 'Goldsturm'	*Rudbeckia fulgida* 'Goldsturm'
31	Rudbeckia 'Indian Summer'	*Rudbeckia hirta* 'Indian Summer'
32	Three-Lobed Coneflower	*Rudbeckia triloba*
33	Mexican Petunia 'Purple Showers'	*Ruellia brittoniana* 'Purple Showers'
34	Salvia 'Hot Lips'	*Salvia microphylla* 'Hot Lips'
35	Yarrow 'Sunny Seduction'	*Achillea millefolium* 'Sunny Seduction'
36	Zinnia 'Profusion Deep Apricot'	*Zinnia e. x angustifolia* 'Profusion Deep Apricot'
37	Hummingbird Plant	*Dicliptera suberecta*
38	Lantana 'Pink Caprice'	*Lantana camara* 'Pink Caprice'
39	Blue Beard 'First Choice'	*Caryopteris x clandonensis* 'First Choice'

Table 4.17. Influence of plant type and sweep net sampling date on occurrence of pollinating and beneficial insect taxa collected over a seven-date period from June 10-July 22, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding Co., GA) (more information provided in Table A.5).

Insect Taxa	**Degrees of Freedom**		**P-Value**		**F-Value**	
	Plant Type	Date	Plant Type	Date	Plant Type	Date
Dolichopodidae	38, 878	6, 878	<0.0001***	<0.0001***	2.31	4.75
Bombyliidae	38, 878	6, 878	0.7675	0.4860	0.82	0.91
Bumble Bees	38, 878	6, 878	<0.0001***	0.1035	4.46	1.76
Carpenter Bees	38, 878	6, 878	<0.0001***	0.6232	3.60	0.73
Mordellidae	38, 878	6, 878	0.0022**	0.0112**	1.81	2.77
Muscidae	38, 878	6, 878	0.0691	0.0478*	1.37	2.13
Sarcophagidae	38, 878	6, 878	0.8106	0.3444	0.79	1.13
Small Bees	38, 878	6, 878	<0.0001***	<0.0001***	3.95	11.9
Sphecidae	38, 879	6, 879	0.8464	0.5713	0.77	0.80
Syrphidae	38, 878	6, 878	<0.0001***	0.0003***	3.03	4.30
Tachinidae	38, 878	6, 878	0.8405	0.0860	0.77	1.85
Ulidiidae	38, 878	6, 878	0.1433	0.0513*	1.25	2.10
Vespidae	38, 878	6, 878	0.8632	0.4445	0.75	0.97
Yponomeutidae	38, 878	6, 878	0.2579	0.0081**	1.14	2.91
Amblyscirtes aenus	38, 878	6, 878	0.4288	0.4578	1.03	0.95
Apis mellifera	38, 878	6, 878	0.0418*	0.5628	1.45	0.81
Epargyreus clarus	38, 879	6, 879	0.8259	0.3841	0.78	0.81
Eurema nicippe	38, 878	6, 878	0.8494	0.0772	0.76	1.91
Hemaris species	38, 878	6, 878	0.0026**	0.4927	1.79	0.90
Hylephila phyleus	38, 878	6, 878	0.0004***	0.1006	2.00	1.78
Junonia coenia	38, 878	6, 878	0.0233*	0.0083**	1.53	2.90
Papilio glaucus	38, 878	6, 878	0.5893	0.5046	0.93	0.89
Strymon melinus	38, 878	6, 878	0.8118	0.4780	0.79	0.92
Trypoxylon politum	38, 878	6, 878	0.0770	0.0190**	1.35	2.54
Vanessa species	38, 878	6, 878	0.7135	0.3996	0.86	1.04
All Pollinators Combined	38, 877	6, 877	<0.0001***	<0.0001***	3.27	7.18

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

Table 4.17. (Continued). Influence of plant type and sweep net sampling date on occurrence of pollinating and beneficial insect taxa collected over a seven-date period from June 10-July 22, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding Co., GA) (more information provided in Table A.5).

Insect Taxa	**Degrees of Freedom** Plant Type	Date	**P-Value** Plant Type	Date	**F-Value** Plant Type	Date
Anthocoridae	38, 878	6, 878	0.8405	0.3424	0.77	1.13
Araneae	38, 877	6, 877	0.0004***	0.0005***	2.01	4.09
Cantharidae	38, 878	6, 878	0.0109**	0.0167**	1.62	2.60
Chrysopidae	38, 878	6, 878	0.1902	0.3350	1.20	1.14
Coccinellidae	38, 878	6, 878	0.2454	0.2468	1.15	1.32
Formicidae	38, 877	6, 877	0.1141	0.0479*	1.29	2.13
Miridae	38, 878	6, 878	<0.0001***	0.0041**	4.42	3.20
Nabidae	38, 878	6, 878	0.0192**	<0.0001***	1.55	5.18
Oecanthinae	38, 877	6, 877	0.2801	0.0832	1.13	1.87
Pentatomidae	38, 878	6, 878	<0.0001***	0.5038	2.28	0.89
Parasitic Hymenoptera	38, 878	6, 878	0.0770	0.0190**	1.35	2.54
Reduviidae	38, 878	6, 878	0.6659	0.1983	0.89	1.43
Geocoris punctipes	38, 878	6, 878	<0.0001***	0.0577	4.81	2.04
All Beneficial Insects Combined	38, 877	6, 877	<0.0001***	0.0002***	2.98	4.41

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

Table 4.18. Comparison for mean (± S.E.) of pollinating and beneficial insect taxa collected in sweep net samples from thirty-nine plant types over a seven-date period from June 10-July 22, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

	Date						
Insect Taxa	June 10	June 17	June 26	July 3	July 8	July 15	July 22
Dolichopodidae	0.07 ± 0.03bc	0.06 ± 0.03bc	**0.22 ± 0.06a**	0.07 ± 0.02bc	0.15 ± 0.04ab	0.00 ± 0.00c	0.13 ± 0.04abc
Mordellidae	**0.21 ± 0.11a**	**0.10 ± 0.03ab**	**0.07 ± 0.04ab**	0.03 ± 0.02b	**0.08 ± 0.03ab**	0.01 ± 0.01b	0.01 ± 0.01b
Muscidae	0.05 ± 0.02ab	0.05 ± 0.03ab	**0.12 ± 0.03a**	0.07 ± 0.02ab	0.05 ± 0.02ab	0.01 ± 0.01b	0.02 ± 0.01b
Small Bees	0.20 ± 0.07b	0.20 ± 0.06b	0.38 ± 0.08b	0.12 ± 0.03b	0.11 ± 0.02b	0.35 ± 0.14b	**1.43 ± 0.25a**
Syrphidae	0.07 ± 0.03ab	**0.19 ± 0.05a**	0.13 ± 0.04ab	0.12 ± 0.03ab	0.11 ± 0.03ab	0.01 ± 0.01b	0.02 ± 0.01b
Ulidiidae	0.05 ± 0.02a	0.05 ± 0.02a	0.08 ± 0.03a	0.03 ± 0.02a	0.01 ± 0.01a	0.01 ± 0.01a	0.05 ± 0.02a
Yponomeutidae	0.00 ± 0.00a	0.01 ± 0.01a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.03 ± 0.01a
Junonia coenia	**0.05 ± 0.02a**	0.04 ± 0.02ab	0.03 ± 0.02ab	0.02 ± 0.02ab	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b
Trypoxylon politum	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	**0.01 ± 0.01a**
All Pollinators Combined	0.87 ± 0.18b	0.82 ± 0.12b	1.18 ± 0.16ab	1.11 ± 0.16ab	0.99 ± 0.11b	0.50 ± 0.17b	**1.83 ± 0.27a**
Araneae	0.03 ± 0.05ab	**0.31 ± 0.07a**	0.20 ± 0.50abc	0.18 ±0.04abc	0.12 ± 0.03bc	0.06± 0.02c	0.14 ± 0.03bc
Cantharidae	0.00 ± 0.00a	0.03 ± 0.02a	0.02 ± 0.01a	0.00 ± 0.00a	0.00 ± 0.00a	0.00± 0.00a	0.00 ± 0.00a
Formicidae	0.08 ± 0.04a	0.07 ± 0.03a	0.03 ± 0.02a	0.02 ± 0.01a	0.06 ± 0.03a	0.01 ± 0.01a	0.01 ± 0.01a
Miridae	0.28 ± 0.07ab	**0.44 ± 0.11a**	0.25 ± 0.06ab	0.34 ± 0.08ab	0.31 ± 0.06ab	0.11 ± 0.03b	0.15 ± 0.04b
Nabidae	0.01 ± 0.01c	0.06 ± 0.03bc	0.07 ± 0.03abc	0.15 ± 0.03ab	0.12 ±0.04abc	0.01 ± 0.01bc	**0.20 ± 0.05a**
Parasitic Hymenoptera	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.01 ± 0.01a
Geocoris punctipes	0.05 ± 0.04a	0.18 ± 0.05a	0.24 ± 0.08a	0.10 ± 0.04a	0.25 ± 0.07a	0.11 ± 0.05a	0.15 ± 0.03a
All Beneficial Insects Combined	0.83 ± 0.13ab	**1.53 ± 0.24a**	**1.59 ± 0.44a**	**1.14 ± 0.18a**	1.00 ± 0.11ab	0.32 ± 0.07b	0.85 ± 0.10ab

Means in the same row bearing different letters are significantly different (α=0.05).

Table 4.19. Comparison for mean (± S.E.) of pollinating insect taxa collected in sweep net samples from thirty-nine plant types over a seven-date period from June 10-July 22, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Dolichpodidae	Bumble Bees	Carpenter Bees	Mordellidae	Small Bees	Syrphidae	*A.mellifera*	*Hemaris* species	*H. phyleus*	*J. coenia*	All Pollinators Combined
1	0.04 ± 0.04b	0.00 ± 0.00b	0.04 ± 0.04b	0.00±0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.08 ±0.08ab	1.32 ± 0.28b
2	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	**0.41 ± 0.15a**	0.00 ± 0.00a	0.06 ± 0.06b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.76 ± 0.24b
3	0.00 ± 0.00b	0.00 ± 0.00b	0.13 ± 0.09b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.50 ± 0.20b
4	0.04 ± 0.04b	0.00 ± 0.00b	0.17 ± 0.08b	0.08 ± 0.06a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.25 ±0.14ab	1.08 ± 0.38b
5	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	**0.30 ± 0.13a**	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.85 ± 0.34b
6	0.04 ± 0.04b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	1.22 ± 0.36b
7	0.30 ± 0.10ab	0.00 ± 0.00b	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.04 ± 0.04b	0.96 ± 0.28b
8	0.14 ± 0.07ab	0.00 ± 0.00b	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.04 ± 0.04a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.07 ±0.07ab	1.75 ±0.29ab
9	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.05 ± 0.05b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	**0.05 ± 0.05a**	0.18 ± 0.11ab	0.36 ± 0.17b
10	0.00 ± 0.00b	0.00 ± 0.00b	0.05 ± 0.05b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.62 ± 0.22b
11	0.12 ± 0.06ab	0.00 ± 0.00b	0.08 ± 0.05b	0.08 ± 0.05a	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.04 ± 0.04a	0.00 ± 0.00b	0.12 ± 0.06ab	0.81 ± 0.25b
12	0.12 ± 0.06ab	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.68 ± 0.21b
13	0.08 ± 0.06b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.08 ± 0.08ab	0.64 ± 0.20b
14	0.11 ± 0.08ab	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.72 ± 0.24b
15	0.00 ± 0.00b	0.00 ± 0.00b	0.11 ± 0.08b	0.00 ± 0.00a	0.07 ± 0.05b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.07 ± 0.05ab	1.75 ±0.32ab
16	0.07 ± 0.07b	0.00 ± 0.00b	0.07 ± 0.05b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.11 ± 0.08b	0.00 ± 0.00a	0.00 ± 0.00b	0.07 ± 0.05ab	**3.89 ± 1.12a**
17	0.38 ± 0.16ab	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.81 ± 0.21b
18	0.11 ± 0.06ab	0.00 ± 0.00b	0.07 ± 0.07b	0.00 ± 0.00a	0.00 ± 0.00b	0.04 ± 0.04a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.66 ± 0.25b
19	0.04 ± 0.04b	0.00 ± 0.00b	**0.72 ± 0.44a**	0.00 ± 0.00a	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	1.36 ± 0.59b
20	0.11 ± 0.07ab	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.26 ± 0.10b
21	0.00 ± 0.00b	0.00 ± 0.00b	0.05 ± 0.05b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.45 ± 0.23b
22	0.21 ± 0.11ab	0.00 ± 0.00b	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	2.21 ±0.58ab
23	0.11 ± 0.06ab	0.00 ± 0.00b	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.68 ± 0.24b
24	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.08 ± 0.08a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.33 ± 0.14b
25	0.10 ± 0.07ab	0.00 ± 0.00b	0.05 ± 0.05b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	**0.40 ± 0.18a**	0.90 ± 0.27b

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.19. (Continued). Comparison for mean (± S.E.) of pollinating insect taxa collected in sweep net samples from thirty-nine plant types over a seven-date period from June 10-July 22, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Dolichpodidae	Bumble Bees	Carpenter Bees	Mordellidae	Small Bees	Syrphidae	*A.mellifera*	*Hemaris* species	*H. phyleus*	*J. coenia*	All Pollinators Combined
26	0.05 ± 0.05b	0.00 ±0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.40 ± 0.13b
27	0.00 ± 0.00b	0.00 ± 0.00b	0.16 ± 0.07b	0.00 ± 0.00a	0.12 ± 0.07b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.08 ± 0.08ab	1.12 ± 0.27b
28	**0.56 ± 0.25a**	0.00 ± 0.00b	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	1.07 ± 0.28b
29	0.25 ± 0.11ab	0.00 ± 0.00b	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.75 ± 0.27b
30	0.11 ± 0.06ab	0.00 ± 0.00b	0.11 ± 0.08b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	1.63 ± 0.53ab
31	0.15 ± 0.09ab	0.00 ± 0.00b	0.15 ± 0.07b	0.00 ± 0.00a	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.08 ± 0.08ab	1.69 ± 0.58ab
32	0.00 ± 0.00b	0.00 ± 0.00b	0.05 ± 0.05b	0.05 ± 0.05a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	1.36 ± 0.78b
33	0.13 ± 0.09ab	**0.13 ± 0.13a**	0.00 ± 0.00b	0.00 ± 0.00a	0.06 ± 0.06b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.50 ± 0.18b
34	0.11 ± 0.06ab	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.15 ± 0.10ab	0.85 ± 0.20b
35	0.04 ± 0.04b	0.00 ± 0.00b	**0.22±0.14ab**	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	1.52 ± 0.43ab
36	0.00 ± 0.00b	0.00 ± 0.00b	0.04 ± 0.04b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.44 ± 0.18b
37	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.33 ± 0.19b
38	0.07 ± 0.07b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.20 ± 0.14b
39	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00b	0.50 ± 0.50b

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.20. Comparison for mean (± S.E.) of beneficial insect taxa collected in sweep net samples from thirty-nine plant types over a seven-date period from June 10-July 22, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Araneae	Cantharidae	Miridae	Nabidae	Pentatomidae	*G. punctipes*	All Beneficial Insects Combined
1	0.04 ± 0.04a	0.04 ± 0.04a	0.44 ± 0.15a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.96 ± 0.23bc
2	0.00 ± 0.00a	0.18 ± 0.10a	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.41 ± 0.24bc
3	0.00 ± 0.00a	0.00 ± 0.00a	0.13 ± 0.09a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.75 ± 0.41bc
4	0.00 ± 0.00a	0.08 ± 0.06a	0.25 ± 0.11a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.71 ± 0.19bc
5	0.00 ± 0.00a	0.00 ± 0.00a	0.10 ± 0.10a	0.10 ± 0.10b	0.00 ± 0.00a	0.00 ± 0.00a	0.65 ± 0.25bc
6	0.04 ± 0.04a	0.15 ± 0.12a	0.07 ± 0.05a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.77 ± 0.20bc
7	0.00 ± 0.00a	0.12 ± 0.06a	0.12 ± 0.08a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.50 ± 0.14bc
8	0.00 ± 0.00a	0.25 ± 0.10a	0.25 ± 0.11a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.82 ± 0.19bc
9	0.00 ± 0.00a	0.00 ± 0.00a	0.05 ± 0.05a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.27 ± 0.13bc
10	0.14 ± 0.14a	0.10 ± 0.07a	0.15 ± 0.10a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	1.29 ± 0.55bc
11	0.08 ± 0.05a	0.00 ± 0.00a	0.31 ± 0.14a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	2.81 ± 0.70ab
12	0.00 ± 0.00a	0.04 ± 0.04a	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.04 ± 0.04a	0.32 ± 0.11bc
13	0.08 ± 0.06a	0.12± 0.07a	0.44 ± 0.14a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.80 ± 0.18bc
14	0.17 ± 0.09a	0.17 ± 0.12a	0.17 ± 0.12a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.72 ± 0.24bc
15	0.11 ± 0.08a	0.25 ± 0.11a	0.46 ± 0.13a	0.00 ± 0.00b	0.00 ± 0.00a	0.07 ± 0.07a	2.71 ± 0.38abc
16	0.00 ± 0.00a	0.21 ± 0.09a	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	1.96 ± 0.48abc
17	0.00 ± 0.00a	0.00 ± 0.00a	0.33 ± 0.13a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.76 ± 0.18bc
18	0.00 ± 0.00a	0.04 ± 0.04a	0.11 ± 0.06a	0.00 ± 0.00b	0.00 ± 0.00a	0.04 ± 0.04a	1.44 ± 0.70abc
19	0.00 ± 0.00a	0.04 ± 0.04a	0.08 ± 0.06a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	1.08 ± 0.45bc
20	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.32 ± 0.13bc
21	0.00 ± 0.00a	0.05 ± 0.05a	0.00 ± 0.00a	0.00 ± 0.00b	0.05 ± 0.05a	0.00 ± 0.00a	0.75 ± 0.28bc
22	0.04 ± 0.04a	0.04 ± 0.04a	0.36 ± 0.11a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.79 ± 0.19bc
23	0.11 ± 0.08a	0.18 ± 0.07a	0.11 ± 0.06a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.82 ± 0.15bc
24	0.00 ± 0.00a	0.00 ± 0.00a	0.08 ± 0.08a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.50 ± 0.23bc
25	0.00 ± 0.00a	0.00 ± 0.00a	0.30 ± 0.13a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.75 ± 0.18bc

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.20 (Continued). Comparison for mean (± S.E.) of beneficial insect taxa collected in sweep net samples from thirty-nine plant types over a seven-date period from June 10-July 22, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Plant Type	Araneae	Cantharidae	Miridae	Nabidae	Pentatomidae	*G. punctipes*	All Beneficial Insects Combined
26	0.00 ± 0.00a	0.35 ± 0.25a	0.10 ± 0.07a	**0.85 ± 0.85a**	0.00 ± 0.00a	0.00 ± 0.00a	1.05 ± 0.39bc
27	0.00 ± 0.00a	0.00 ± 0.00a	0.36 ± 0.16a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.76 ± 0.28bc
28	0.04 ± 0.04a	0.11 ± 0.06a	0.15 ± 0.09a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.59 ± 0.22bc
29	0.15 ± 0.11a	0.07 ± 0.05a	0.11 ± 0.08a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.54 ± 0.18bc
30	0.00 ± 0.00a	0.00 ± 0.00a	0.19 ± 0.08a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.52 ± 0.12bc
31	0.00 ± 0.00a	0.08 ± 0.05a	0.12 ± 0.06a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	1.00 ± 0.21bc
32	0.18 ± 0.08a	0.09 ± 0.06a	0.18 ± 0.11a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	**4.05 ± 2.08a**
33	0.06 ± 0.06a	0.19 ± 0.14a	0.00 ± 0.00a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.81 ± 0.29bc
34	0.15 ± 0.07a	0.30 ± 0.13a	0.22 ± 0.08a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	1.33 ± 0.33bc
35	0.00 ± 0.00a	0.09 ± 0.06a	0.13 ± 0.07a	0.00 ± 0.00b	0.00 ± 0.00a	0.04 ± 0.04a	1.09 ± 0.23bc
36	0.04 ± 0.04a	0.00 ± 0.00a	0.19 ± 0.09a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.59 ± 0.15bc
37	0.07 ± 0.07a	0.07 ± 0.07a	0.07 ± 0.07a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.47 ± 0.19bc
38	0.00 ± 0.00a	0.00 ± 0.00a	0.13 ± 0.09a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	0.13 ± 0.09c
39	0.00 ± 0.00a	0.25 ± 0.25a	0.50 ± 0.29a	0.00 ± 0.00b	0.00 ± 0.00a	0.00 ± 0.00a	2.25 ± 1.03abc

Means in the same column bearing different letters are significantly different (α=0.05).

Table 4.21. Influence of sticky trap height and sticky trap collection date on pollinating, beneficial, and plant-feeding insect taxa occurrences collected over and eight-date period from June 3-August 5, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding Co., GA) (more information provided in Table A.6).

Insect Taxa	Degrees of Freedom		P-Value		F-Value	
	Date	Trap Height	Date	Trap Height	Date	Trap Height
Dolichopodidae	7, 63	1, 63	<0.0001***	0.0015**	5.86	11.29
Syrphidae	7, 63	1, 63	0.1151	0.8150	1.76	0.06
Chironomidae	7, 63	1, 63	0.0777	0.0016**	1.97	11.10
Other Flies	7, 63	1, 63	0.2648	0.5787	1.46	0.31
Mordellidae	7, 63	1, 63	0.0528	0.0945	2.16	2.90
All Pollinators Combined	7, 63	1, 63	0.1115	0.0297*	1.78	4.99
Parasitic Hymenoptera	7, 63	1, 63	0.0005***	0.8797	4.56	0.02
Formicidae	7, 63	1, 63	0.0752	0.6407	1.98	0.22
Miridae	7, 63	1, 63	0.2678	0.5637	1.30	0.34
Pentatomidae	7, 63	1, 63	0.4420	0.3219	1.00	1.00
All Beneficial Insects Combined	7, 63	1, 63	0.0015**	0.9601	3.98	0.00
Cicadellidae	7, 63	1, 63	0.4430	0.0147*	1.00	6.36
Rhyparochromidae	7, 63	1, 63	0.4420	0.3219	1.00	1.00
Chrysomelidae	7, 63	1, 63	0.0395*	0.8734	2.31	0.03
Curculionidae	7, 63	1, 63	0.1437	0.5449	1.64	0.37
Elateridae	7, 63	1, 63	0.5709	1.0000	0.83	0.00
All Plant-Feeding Insects Combined	7, 63	1, 63	0.5506	0.0175*	0.85	6.02

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

Table 4.22. Comparison for mean (± S.E.) of pollinating, beneficial, and plant-feeding insect taxa collected on sticky traps at 2-foot and 4-foot over an eight-date period from June 3-August 5, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding Co., GA).

Insect Taxa	**Trap Height**	
	2 ft. Trap	4 ft. Trap
Dolichopodidae	1.97 ± 0.42b	**4.41 ± 0.81a**
Syrphidae	0.16 ± 0.10a	0.19 ± 0.09a
Chironomidae	**29.8 ± 4.25a**	17.9 ± 1.91b
Other Flies	1.94 ± 0.91a	2.53 ± 0.61a
Mordellidae	0.25 ± 0.12a	0.53 ± 0.13a
All Pollinators Combined	**34.1 ± 4.30a**	25.6 ± 2.03b
Parasitic Hymenoptera	4.16 ± 0.59a	4.06 ± 0.46a
Formicidae	0.03 ± 0.03a	0.06 ± 0.06a
Miridae	0.13 ± 0.06a	0.19 ± 0.09a
Pentatomidae	0.00 ± 0.00a	0.03 ± 0.03a
All Beneficial Insects Combined	4.31 ± 0.58a	4.34 ± 0.45a
Cicadellidae	3.06 ± 0.47b	**4.97 ± 0.57a**
Rhyparochromidae	0.00 ± 0.00a	0.03 ± 0.03a
Chrysomelidae	0.50 ± 0.16a	0.47 ± 0.13a
Curculionidae	0.03 ± 0.03a	0.06 ± 0.03a
Elateridae	0.03 ± 0.03a	0.03 ± 0.03a
All Plant-Feeding Insects Combined	3.63 ± 0.49b	**5.56 ± 0.59a**

Means in the same row bearing different letters are significantly different (α=0.05).

Table 4.23. Comparison for mean (± S.E.) of pollinating, beneficial, and plant-feeding insect taxa collected on sticky traps at two different trap heights over an eight-date period from June 3-August 5, 2014 in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

	Date							
Insect Taxa	Jun3-Jun10	Jun10-Jun17	Jun17-Jun25	Jul1-Jul8	Jul8-Jul15	Jul15-Jul22	Jul22-Jul28	Jul28-Aug5
Dolichopodidae	**5.00 ± 1.27ab**	**8.25 ± 2.24a**	3.38 ± 0.96b	1.13 ± 0.35b	3.50 ± 1.31b	1.63 ± 0.50b	1.75 ± 0.84b	0.88 ± 0.35b
Syrphidae	0.13 ± 0.13a	0.50 ± 0.33a	0.63 ± 0.38a	0.00 ± 0.00a	0.00 ± 0.00a	0.13 ± 0.13a	0.00 ± 0.00a	0.00 ± 0.00a
Chironomidae	21.9 ± 5.92a	19.8 ± 7.01a	24.5 ± 7.42a	16.1 ± 2.79a	25.0 ± 8.48a	29.4 ± 5.38a	37.4 ± 10.9a	16.6 ± 2.80a
Other Flies	4.25 ± 2.16a	2.38 ± 0.63a	5.63 ± 3.45a	2.00 ± 0.71a	1.00 ± 0.57a	1.13 ± 0.40a	0.38 ± 0.26a	1.13 ± 0.44a
Mordellidae	0.63 ± 0.26a	0.13 ± 0.13a	0.88 ± 0.40a	0.50 ± 0.27a	0.75 ± 0.32a	0.25 ± 0.16a	0.00 ± 0.00a	0.00 ±0.00a
All Pollinators Combined	31.9 ± 6.67a	31.0 ± 7.70a	35.0 ± 6.35a	19.8 ± 2.56a	30.3 ± 8.53a	32.5 ± 5.16a	39.5 ± 10.5a	18.6 ± 3.30a
Parasitic Hymenoptera	**5.50 ± 0.78ab**	2.75 ± 0.53b	2.75 ± 0.56b	2.50 ± 0.38b	**4.63 ± 1.26ab**	**4.75 ± 1.10ab**	**7.63 ± 1.25a**	2.38 ± 0.9b
Formicidae	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.38 ± 0.26a
Miridae	0.13 ± 0.13a	0.00 ± 0.00a	0.00 ± 0.00a	0.25 ± 0.16a	0.25 ± 0.25a	0.13 ± 0.13a	0.00 ± 0.00a	0.50 ± 0.27a
Pentatomidae	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.13 ± 0.13a
All Beneficial Insects Combined	**5.63 ± 0.80ab**	2.75 ± 0.53b	2.75 ±0.56b	2.75 ± 0.32b	**4.88 ± 1.26ab**	**4.88 ±1.09ab**	**7.63 ± 1.25a**	3.38 ± 0.96b
Cicadellidae	4.50 ± 1.50a	5.88 ± 1.86a	4.50 ± 1.25a	2.25 ± 0.37a	3.25 ± 0.53a	4.38 ± 0.82a	3.75 ± 0.59a	3.63 ± 0.92a
Rhyparochromidae	0.00 ± 0.00a	0.00 ± 0.00a	0.13 ± 0.13a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a
Chrysomelidae	0.88 ± 0.35a	0.25 ± 0.25a	0.00 ± 0.00a	0.75 ± 0.25a	0.63 ± 0.38a	0.25 ± 0.16a	1.13 ± 0.40a	0.00 ± 0.00a
Curculionidae	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.13 ± 0.13a	0.00 ± 0.00a	0.25 ± 0.16a	0.00 ± 0.00a
Elateridae	0.13 ± 0.13a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.13 ± 0.13a	0.00 ± 0.00a
All Plant-Feeding Insects Combined	5.50 ± 1.69a	6.13 ± 1.86a	4.63 ± 1.27a	3.00 ± 0.50a	4.00 ± 0.42a	4.63 ±0.75a	5.25 ± 0.77a	3.63 ± 0.92a

Means in the same row bearing different letters are significantly different (α=0.05).

Figure 4.1. Master Gardener volunteers collecting visual observations over seventy-five plant types in each of the four replications of the UGA Butterfly and Conservation Garden (Spalding, Co., GA)

CHAPTER 5

CONCLUSION

The series of studies reported herein have further elucidated the potential to attract urban pollinator, beneficial, and butterfly populations by choosing appropriate plant parameters as well as provided information on occurrences and activity of beneficial and pollinating insect taxa of southeastern gardens. Through surveying, the potential to improve public perception of arthropods and arthropod-related benefits was assessed, suggesting entomology education could be utilized as a useful tool to improve attitudes toward arthropods. Our findings confirmed suppression of the lantana lace bug, *Teleonemia scrupulosa* Stål, through the use of multiple systemic insecticides (Safari® 20 SG and Merit® 75 WP) with minimal deleterious effects on the common buckeye butterfly, *Junonia coenia* Hübner, although, these neonicotinoid insecticides are under intense scrutiny for their potential deleterious effects on hymenopterans and other natural enemies. The main goals of these studies were to survey visitation of pollinating and beneficial insects as affected by plant type as well as to assess plant types deemed appropriate for southeastern landscapes, determine potential to improve public perception of arthropods and their benefits, and evaluate a series of systemic and non-residual insecticides for their effects on *Teleonemia scrupulosa* and *Junonia coenia*.

In Fall 2012, the UGA Butterfly and Conservation Gardens were created, containing 74-76 commercially grown perennial, annual, and native plant species selected on the basis of their attractiveness to urban pollinators, beneficials, and butterflies and their ability to grow in southeastern gardens. To assess these plant types and monitor visitation of beneficial arthropods, visual observations were implemented biweekly in Summer 2013 and weekly in Fall 2013, indicating occurrences of bumble bees (F: Apidae), other bees (i.e. carpenter bees and honeybees), small bees, long-legged flies (F: Dolichopodidae), hoverflies (F: Syrphidae), house flies (F: Muscidae), tumbling flower beetles (F: Mordellidae), skippers (F: Hesperiidae), sulphur and white butterflies (F: Pieridae), common buckeye butterflies (*J. coenia*), painted lady butterflies (*Vanessa* sp.), and eastern swallowtail butterflies (*Papilio glaucus*). Robber flies (F: Asilidae), predatory soldier beetles (F: Cantharidae) and plant bugs (F: Miridae), fireflies (F: Lampyridae), predaceous tree crickets (SF: Oecanthinae), predatory stink bugs (F: Pentatomidae), and big-eyed bugs (*Geocoris punctipes* Say) also occurred. Preferred floral resources for pollinating and beneficial arthropods determined through visual observations included Anise Hyssop 'Black Adder' (*Agastache* (Pursh) Kuntze 'Black Adder'), Gaura 'Passionate Blush (*Gaura lindheimeri* Engelm 'Passionate Blush'), Celosia (*Celosia spicata L.*), and Coleus Fuseables (*Solenostemon scutellariodes* L.).

Similar pollinating and beneficial insect occurrences were demonstrated among the multiple trapping methods (pan trapping, sticky trapping, and sweep-net sampling) utilized in Summer 2013 and 2014. Multiple sampling methods were employed to provide a complete picture of the beneficial insect taxa visiting the UGA Butterfly and Conservation Garden. Through the use of pan trapping, 16 species of small bees were identified with *Halictus ligatus* Say *and Lasioglossum (dialictus) imitatum* Smith being the most common species. Additional groups collected through pan trapping in 2013 and 2014 included chalcid wasps (SF: Chalcidoidea), stem sawflies (F: Cephidae), non-biting midges (F: Chironomidae) fruit flies (F: Tephritidae), other flies, ground beetles (F: Carabidae), predatory ants (F: Formicidae), and rove beetles (F: Staphylindae). This study also demonstrated yellow bowls positioned on the ground as a primary trap type for collecting beneficial bees, flies, and wasps.

Likewise, yellow sticky trapping also collected parasitic Hymenoptera that were not discovered through visual observations and pan trapping and revealed sticky traps should be placed at both two- and four-foot heights to adequately survey beneficial and pollinating insect taxa occurrences. Sweep-net sampling revealed occurrences of carpenter bees (F: Apidae), picture-winged flies (F: Ulidiidae), fiery skippers (*Hylephila phyleus),* spiders (O: Araneae), and predatory damsel bugs (F: Nabidae) which was not previously observed and captured through pan and sticky trapp*ing*. Floral favorites of pollinating and beneficial arthropods as indicated through sweep-net sampling consisted of Celosia (*Celosia spicata L.*) and Three-Lobed Coneflower (*Rudbeckia triloba* L.). Studying the visitation and occurrence of pollinator, beneficial, and butterfly populations along with their preferred floral resources can provide the public with the appropriate information needed to attract pollinators, beneficials, and butterflies to their own gardens, ultimately experiencing the ecosystem services that these insects provide.

Public perception of arthropods and arthropod-related benefits is essential to the acceptance of these beneficial "bugs" to a garden. Insects such as the sulphur (F: Pieridae), gulf fritillary (F: Nymphalidae), and eastern swallowtail (F: Papilionidae) butterfly and the lady beetle (F: Coccinellidae) were commonly ranked higher than the stink bug (F: Pentatomidae), assassin bug (F: Reduviidae), paper wasp (F: Vespidae), and wolf spider (F: Lycosidae). However, all insects surveyed provide ecosystem services in the form of pollination, biological control, and decomposition. Some factors that contributed to the ranking and perception of the beneficial arthropods was age and amount of entomology education. Examining the opportunity to increase public perception of arthropod and arthropod-related benefits, revealed the use of entomology education as a platform to improve or change negativistic attitudes towards certain arthropods including the stink bug (F: Pentatomidae), assassin bug (F: Reduviidae), paper wasp (F: Vespidae), and wolf spider (F: Lycosidae) which were commonly ranked lowest.

Assessing insecticides for their effect on pollinating lepidopterans such as the common buckeye butterfly (*Junonia coenia*) and suppression of the lantana lace bug (*Teleonemia scrupulosa*) is also important for conservation of butterflies and control of insect pests such as *Teleonemia scrupulosa*. With the exception of chlorantraniliprole (Acelypryn™), lace bug-targeted materials had similar effects on *J. coenia* adults during the three-week exposure period with imidacloprid (Merit® 75 WP) and dinotefuran (Safari® 20 SG) comparable to the control. Neonicotinoid insecticides (i.e. imidacloprid and dinotefuran) have minimal effects on lepidopterans but severely affect hymenopterans and other natural enemies. However, chlorantraniliprole (Acelypryn™) affect Lepidoptera but are not reported to harm Hymenoptera. Although lepidopteran mortality was higher, alternative insecticides (i.e. M-Pede® Insecticidal Soap, Ultra-Pure™ Horticultural Oil, and Garden Safe™ Neem Oil) may be used to control *T. scrupulosa* while limiting effects on pollinators and natural enemies.

Ultimately, the findings of this series of studies can be used to effectively educate the public on plant types that may be grown to attract pollinating and beneficial arthropods as well as inform homeowners about positive services beneficial and pollinating insects may contribute to southeastern landscapes. In turn, if insect pest, *Teleonemia scrupulosa* requires insecticidal use in a garden, alternative insecticides can be used for successful suppression and for conservation of lepidopterans, hymenopterans, and other natural enemies.

APPENDIX

2013 Summer Visual Observations. Occurrence of potential pollinating groups which were observed included bumble bees (F: Apidae) (P=<0.0001, $F_{89,4391}$=11.67), small bees (P=<0.0001, $F_{89,4391}$=5.92) (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say), other bees (i.e. carpenter bees and honeybees) (P=<0.0001, $F_{89,4391}$=3.54) (Table A.1). Long-legged flies (F: Dolichopodidae) (P=<0.0001, $F_{89,4391}$=4.34), house flies (F: Muscidae) (P=<0.0001, $F_{89,4391}$=3.04), and hoverflies (F: Syrphidae) (P=<0.0001, $F_{89,4391}$=3.35) were also observed throughout the four replications of the UGA Butterfly and Conservation Garden (Table A.1). Some non-bee and non-fly pollinator visiting included the pollinating, tumbling flower beetles (F: Mordellidae) (P=<0.0001, $F_{89,4391}$=7.91), skipper butterflies (F: Hesperiidae) (P=<0.0001, $F_{89,4391}$=2.69), sulphur and white butterflies (F: Pieridae) (P=<0.0001, $F_{89,4391}$=9.51) and the common buckeye butterflies (*Junonia coenia* Hübner) (P=<0.0001, $F_{89,4391}$=2.48). The "All Pollinators Combined" assemblage occurred significantly over the four replications of the UGA Butterfly and Conservation Garden (P=<0.0001, $F_{89,4391}$=8.26) (Table A.1).

Beneficial insects which were observed in abundance during visual observations include robber flies (F: Asilidae) (P=<0.0001, $F_{89,4391}$=1.92), predatory soldier beetles (F: Cantharidae) (P=<0.0001, $F_{89,4391}$=4.03) and fireflies (F: Lampyridae) (P=<0.0001, $F_{89,4390}$=4.16) (Table A.1). Likewise, predatory plant bugs (F: Miridae) (P=<0.0001, $F_{89,4391}$=4.03), predacious tree crickets (SF: Oecanthinae) (P=<0.0001, $F_{89,4391}$=3.81), and predatory stink bugs (F: Pentatomidae) (P=<0.0001, $F_{89,4390}$=2.04) were significantly observed during visual observations. Predatory big-eyed bug (*Geocoris punctipes* Say) (P=<0.0001, $F_{89,4391}$=2.87) and the "All Beneficial Insects" group (P=<0.0001, $F_{89,4389}$=5.83) significantly occurred over the four replications of the UGA Butterfly and Conservation Garden (Table A.1).

Table A.1. Degrees of freedom, *P*-values, and *F*-values of pollinating and beneficial insect taxa observed during a fourteen-date period from June 4-September 5, 2013 over seventy-four plant types located in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Insect Taxa	Degrees of Freedom	P-Value	F-Value
Bumble Bees	89, 4391	<0.0001***	11.67
Dolichopodidae	89, 4391	<0.0001***	4.34
Hesperiidae	89, 4391	<0.0001***	2.68
Mordellidae	89, 4391	<0.0001***	7.91
Muscidae	89, 4391	<0.0001***	3.04
Other Bees	89, 4391	<0.0001***	3.54
Pieridae	89, 4391	<0.0001***	9.51
Small Bees	89, 4391	<0.0001***	5.92
Syrphidae	89, 4391	<0.0001***	3.35
Junonia coenia	89, 4391	<0.0001***	2.48
All Pollinators Combined	89, 4391	<0.0001***	8.26
Asilidae	89, 4391	<0.0001***	1.92
Cantharidae	89, 4391	<0.0001***	4.03
Lampyridae	89, 4390	<0.0001***	4.16
Miridae	89, 4391	<0.0001***	4.03
Oecanthinae	89, 4391	<0.0001***	3.81
Pentatomidae	89, 4390	<0.0001***	2.04
Geocoris punticpes	89, 4391	<0.0001***	2.87
All Beneficial Insects Combined	89, 4389	<0.0001***	5.83

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

2013 Fall Master Gardener Visual Observations. Over a nineteen-date period from August 26-November 4, Master Gardener volunteers conducted visual observations to determine pollinating insect taxa occurrence and abundance as well as pollinator attractiveness to the seventy-six different plant types (Table 4.5). Some of the pollinating groups which were observed included bumble bees (P=<0.0001, $F_{96,3110}$=5.70), small bees (P=<0.0001, $F_{96,3109}$=3.73) (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say), and other bees (i.e. carpenter bees and honeybees) (P=<0.0001, $F_{96,3111}$=6.82) (Table A.2).

Likewise, Diptera that occurred included long-legged flies (F: Dolichopodidae) (P=<0.0001, $F_{96,3111}$=2.30) and hoverflies (F: Syrphidae) (P=<0.0001, $F_{96,3110}$=3.41). Other non-bee and non-fly pollinators included skipper butterflies (F: Hesperiidae) (P=<0.0001, $F_{96,3090}$=4.46), sulphur and white butterflies (F: Pieridae) (P=<0.0001, $F_{96,3111}$=6.08), painted lady butterflies (*Vanessa* spp.) (P=0.0056, $F_{96,3111}$=1.41), Eastern tiger swallowtail (*Papilio glaucus*) (P=<0.0001, $F_{96,3111}$=1.75), and Common buckeye butterflies (*Junonia coenia*) (P=<0.0001, $F_{96,3111}$=1.84) (Table A.2). Pollinating taxa which were not observed as often included house flies (F: Muscidae) (P=0.0949, $F_{96,3111}$=1.20) and tumbling flower beetles (F: Mordellidae) (P=0.8635, $F_{96,3111}$=0.84) (Table A.2). The "All Pollinators Combined" group was also found significant over the four garden replicates (P=<0.0001, $F_{96,3086}$=8.72) (Table A.2).

Table A.2. Degrees of freedom, *P*-values, and *F*-values of pollinator taxa observed during a nineteen-date period from August 26-November 4, 2013 over seventy-six plant types in the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Insect Taxa	**Degrees of Freedom**	**P-Value**	**F-Value**
Bumble Bees	96, 3110	<0.0001***	5.70
Dolichopodidae	96, 3111	<0.0001***	2.30
Hesperiidae	96, 3090	<0.0001***	4.46
Mordellidae	96, 3111	0.8635	0.84
Muscidae	96, 3111	0.0949	1.20
Other Bees	96, 3111	<0.0001***	6.82
Pieridae	96, 3111	<0.0001***	6.08
Small Bees	96, 3109	<0.0001***	3.73
Syrphidae	96, 3110	<0.0001***	3.41
Vanessa spp.	96, 3111	0.0056**	1.41
Papilio glaucus	96, 3111	<0.0001**	1.75
Junonia coenia	96, 3111	<0.0001**	1.84
All Pollinators Combined	96, 3086	<0.0001***	8.72

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

2013 Pan Trap Sampling. Using pan trapping throughout the four garden replicates, it was determined that pollinators including honeybees, bumble bees, and carpenter bees (F: Apidae) (P=0.0052, $F_{18,136}$=2.24), small bees (P=<0.0001, $F_{18,135}$=3.64) (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say), chalcid wasps (F: Chalcidoidea) (P=<0.0001, $F_{18,136}$=3.66), and stem sawflies (F: Cephidae) (P=0.0013, $F_{18,136}$=2.57) were significantly abundant (Table A.3). Likewise, dipteran groups which predominated trap catches consisted of long-legged flies (F: Dolichopodidae) (P=<0.0001, $F_{18,136}$=6.05), hoverflies (F: Syrphidae) (P=<0.0001, $F_{18,136}$=3.43), fruit flies (F: Tephritidae) P=0.0053, $F_{18,136}$=2.24), and other flies (P=0.0017, $F_{18,136}$=2.51). Other non-bee and non-fly pollinators that were abundantly found throughout the four replications of the UGA Butterfly and Conservation Garden through the use of pan trapping were tumbling flower beetles (F: Mordellidae) (P=<0.0001, $F_{18,136}$=3.92) and skipper butterflies (F: Hesperiidae) (P=0.0019, $F_{18,136}$=2.48) (Table A.3). Likewise, significance of the "All Pollinators Combined" assemblage in which all pollinating insects surveyed through pan trapping were placed into a single group was determined (P=<0.0001, $F_{18,135}$=10.74) (Table A.3).

Beneficial insects were also collected through pan trapping. Some of the most abundant natural enemies collected included robber flies (F: Asilidae) (P=0.0166, $F_{18,136}$=1.97), predatory ground beetles (F: Carabidae) (P=0.0303, $F_{18,136}$=1.82), and predatory ants (F: Formicidae) (P=0.0004, $F_{18,136}$=2.86). Likewise, fireflies (F: Lampyridae) (P=0.0133, $F_{18,136}$=2.02) and rove beetles (F: Staphylinidae) (P=0.0214, $F_{18,136}$=1.91) were collected in high numbers in pan traps (Table A.3). The "All Beneficial Insects Combined" category (P=0.0002, $F_{18,136}$=2.97) in which all beneficial insects collected in pan traps were assembled into a single group, was also significantly abundant (Table A.3).

Pan trapping was also used to survey the abundance and diversity of plant-feeding insects in the four garden replicates. Some of the major plant-feeding taxa that were collected in pan traps including weevils (F: Curculionidae) ($P=0.0332$, $F_{18,136}=1.80$), leafhoppers and sharpshooters (F: Cicadellidae) ($P=<0.0001$, $F_{18,136}=23.82$), and aphids (F: Aphididae) ($P=<0.0001$, $F_{18,136}=5.71$) (Table A.3). Spittlebugs and froghoppers (SF: Cercopoidea) ($P=0.0002$, $F_{18,136}=2.98$) and kudzu bugs (F: Plataspidae) ($P=0.0045$, $F_{18,136}=2.28$) were trapped in high numbers. Significance among the "All Plant-Feeding Insects Combined" assemblage was determined ($P=<0.0001$, $F_{18,136}=18.33$) (Table A.3).

Table A.3. Degrees of freedom, *P*-values, and *F*-values for pollinating, beneficial, and plant-feeding insect taxa sampled through pan trapping over June 20-June 25, 2013 using fourteen different trap types from the UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Insect Taxa	Degrees of Freedom	P-Value	F-Value
Apidae	18, 136	0.0052**	2.24
Chalcidoidea	18, 136	<0.0001***	3.66
Cephidae	18, 136	0.0013**	2.57
Dolichopodidae	18, 136	<0.0001***	6.05
Hesperiidae	18, 136	0.0019**	2.48
Mordellidae	18, 136	<0.0001***	3.92
Other Flies	18, 136	0.0017**	2.51
Small Bees	18, 135	<0.0001***	3.64
Syrphidae	18, 136	<0.0001***	3.43
Tephritidae	18, 136	0.0053**	2.24
All Pollinators Combined	18, 135	<0.0001***	10.74
Asilidae	18, 136	0.0166*	1.97
Carabidae	18, 136	0.0303*	1.82
Formicidae	18, 136	0.0004***	2.86
Lampyridae	18, 136	0.0133*	2.02
Staphylinidae	18, 136	0.0214*	1.91
All Beneficial Insects Combined	18, 136	0.0002***	2.97
Curculionidae	18, 136	0.0332*	1.80
Cicadellidae	18, 136	<0.0001***	23.82
Aphididae	18, 136	<0.0001***	5.71
Cercopoidea	18, 136	0.0002***	2.98
Plataspidae	18, 136	0.0045**	2.28
All Plant-Feeding Insects Combined	18, 136	<0.0001***	18.33

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

2014 Pan Trap Sampling. Using yellow bowl traps on the ground in the four replicates of the UGA Butterfly and Conservation Garden over a seven-date period from June 24-August 4, 2014, it was determined that non-biting midges (F: Chironomidae) (P=0.0284, $F_{10,55}$=2.29), long-legged flies (F: Dolichopodidae) (P=<0.0001, $F_{10,55}$=5.82), tumbling flower beetles (F: Mordellidae) (P=0.0003, $F_{10,55}$=4.27), small bees (P=0.0002, $F_{10,55}$=4.57) (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say), and hoverflies (F: Syrphidae) (P=0.0018, $F_{10,55}$=3.49) were abundant pollinators (Table 4.18). Likewise, the "All Pollinators Combined" assemblage was also significantly abundant (P=<0.0001, $F_{10,55}$=5.34) (Table A.4).

Beneficial insect taxa sampled during 2014 were not significantly abundant over the four replicates of the gardens (Table A.4). However, when all beneficial insect taxa were combined into a single group, "All Beneficial Insects Combined", there was significance (P=0.0450, $F_{10,55}$=2.09) (Table A.4.). Plant-feeding insects including leafhoppers and sharpshooters (F: Cicadellidae) (P=0.0002, $F_{10,55}$=4.55), aphids (F: Aphididae) (P=0.0012, $F_{10,55}$=3.69), spittlebugs and froghoppers (SF: Cercopoidea) (P=0.0490, $F_{10,55}$=2.06), and thrips (F: Thripidae) (P=0.0390, $F_{10,55}$=2.16) were also abundant in the gardens (Table A.4). The "All Plant-Feeding Insects Combined" significantly occurred over the four garden replicates (P=0.0002, $F_{10,55}$=4.62) (Table A.4).

Table A.4. Degrees of freedom, *P*-values, and *F*-values for pollinating, beneficial, and plant-feeding insect taxa collected in the UGA Butterfly and Conservation Gardens (n=4) through pan trapping from June 24-August 4, 2014.

Insect Taxa	Degrees of Freedom	P-Value	F-Value
Apidae	10, 55	0.4579	1.00
Calliphoridae	10, 55	0.6164	0.81
Chironomidae	10, 55	0.0284*	2.29
Dolichopodidae	10, 55	<0.0001***	5.82
Hesperiidae	10, 55	0.7456	0.67
Mordellidae	10, 55	0.0003***	4.27
Muscidae	10, 55	0.1641	1.52
Other Flies	10, 55	0.1375	1.60
Pieridae	10, 55	0.2065	1.41
Sarcophagidae	10, 55	0.4219	1.05
Small Bees	10, 55	0.0002***	4.57
Sphecidae	10, 55	0.5646	0.87
Syrphidae	10, 55	0.0018**	3.49
Tachinidae	10, 55	0.4685	0.99
Ulidiidae	10, 55	0.2931	1.24
Vespidae	10, 55	0.4219	1.05
All Pollinators Combined	10, 55	<0.0001***	5.34
Braconidae	10, 55	0.1789	1.48
Formicidae	10, 55	0.4667	0.99
Ichneumonidae	10, 55	0.6449	0.78
Miridae	10, 55	0.7353	0.68
Oecanthinae	10, 55	0.0974	1.76
Staphylinidae	10, 55	0.4579	1.00
Geocoris punctipes	10, 55	0.3602	1.13
All Beneficial Insects Combined	10, 55	0.0450*	2.09
Curculionidae	10, 55	0.4579	1.00
Chrysomelidae	10, 55	0.2999	1.23
Cicadellidae	10, 55	0.0002***	4.55
Aphididae	10, 55	0.0012**	3.69
Cercopoidea	10, 55	0.0490*	2.06
Thripidae	10, 55	0.0390*	2.16
Scarabaeidae	10, 55	0.4579	1.00
All Plant-Feeding Insects Combined	10, 55	0.0002***	4.62

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

2014 Sweep-Net Sampling. Using sweep-net sampling to survey insect occurrences over the four garden replicates, it was determined that long-legged flies (F: Dolichopodidae) (P=<0.0001, $F_{47,878}$ =2.99), bumble bees (P=<0.0001, $F_{47,878}$ =3.88), carpenter bees (P=<0.0001, $F_{47,878}$ =3.12,), small bees (P=<0.0001, F $F_{47,878}$=4.72) (i.e. *Lasioglossum (dialictus) imitatum* Smith and *Halictus ligatus* Say), and hoverflies (F: Syrphidae) (P=<0.0001, $F_{47,878}$ =3.03) were major pollinators collected over a six-date period from the thirty-nine plant types (Table A.5). Tumbling flower beetles (F: Mordellidae) (P=0.0005, $F_{47,878}$=1.87), picture-winged flies (F: Ulidiidae) (P=0.0526, $F_{47,878}$ =1.37), and house flies (F: Muscidae) (P=0.0405, $F_{47,878}$=1.40) also significantly occurred (Table A.5). The Fiery skipper (*Hylephila phyleus* Drury) (P=0.0004, $F_{47,878}$=1.88) and Common buckeye (*Junonia coenia* Hübner) (P=0.0027, $F_{47,878}$=1.70) butterflies were collected in high numbers throughout the four gardens. Significance (P=<0.0001, $F_{47,877}$=3.50) among the "All Pollinators Combined" assemblage in which all pollinating insects captured in the sweep-net samples were placed into a single group (Table A.5).

The occurrence of natural enemies were also measured through sweep net samples. The most abundant beneficial insects captured included spiders (O: Araneae) (P=<0.0001, $F_{47,877}$=3.50), predatory plant bugs, (F: Miridae) (P=<0.0001, $F_{47,878}$=4.23), predatory damsel bugs (F: Nabidae) (P=<0.0001, $F_{47,878}$=2.59), predatory stink bugs (F: Pentatomidae) (P=<0.0001, $F_{47,878}$=2.11), and *Geocoris punctipes* Say (F: Geocoridae) (P=<0.0001, $F_{47,878}$=4.19). Other predatory insects that were significantly abundant were predatory soldier beetles (F: Cantharidae) (P=0.0045, $F_{47,878}$=1.65), predatory ants (F: Formicidae) (P=0.0116, $F_{47,877}$=1.55), parasitic Hymenoptera (P=0.0308, $F_{47,878}$=1.44), and predacious tree crickets (SF: Oecanthinae) (P=0,0389, $F_{47,877}$=1.41) (Table A.5). Significance (P=<0.0001, $F_{47,877}$=3.09) among the “All Beneficial Insects Combined” category was determined among the four replicates of the UGA Butterfly and Conservation Garden (Table A.5).

Table A.5. Degrees of freedom, *P*-values, and *F*-values of pollinating and beneficial taxa collected from sweep-net samples over a seven-date period from June 10- July 22, 2014 from thirty-nine plant types in UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Insect Taxa	Degrees of Freedom	P-Value	F-Value
Dolichopodidae	47,878	<0.0001***	2.99
Bombyliidae	47, 878	0.7583	0.85
Bumble Bees	47, 878	<0.0001***	3.88
Carpenter Bees	47, 878	<0.0001***	3.12
Mordellidae	47, 878	0.0005***	1.87
Muscidae	47,878	0.0405*	1.40
Sarcophagidae	47, 878	0.7555	0.85
Small Bees	47, 878	<0.0001***	4.72
Sphecidae	47, 879	0.8779	0.76
Syrphidae	47, 878	<0.0001***	3.03
Tachinidae	47, 878	0.6628	0.90
Ulidiidae	47, 878	0.0526*	1.37
Vespidae	47, 878	0.7363	0.86
Yponomeutidae	47, 878	0.0704	1.33
Amblyscirtes aenus	47,878	0.4591	1.01
Apis mellifera	47, 878	0.0669	1.34
Epargyreus clarus	47, 879	0.7792	0.83
Eurema nicippe	47, 878	0.4998	0.99
Hemaris species	47, 878	0.0031	1.69
Hylephila phyleus	47, 878	0.0004***	1.88
Junonia coenia	47, 878	0.0027**	1.70
Papilio glaucus	47, 878	0.6619	0.90
Strymon melinus	47, 878	0.7908	0.83
Trypoxylon politum	47, 878	0.7985	0.82
Vanessa species	47, 878	0.6806	0.89
All Pollinators Combined	47, 877	<0.0001***	3.50
Anthocoridae	47, 878	0.6582	0.90
Araneae	47, 877	<0.0001***	2.35
Cantharidae	47, 878	0.0045**	1.65
Chrysopidae	47, 878	0.2041	1.17
Coccinellidae	47, 878	0.1887	1.18
Formicidae	47, 877	0.0116**	1.55
Miridae	47, 878	<0.0001***	4.23
Nabidae	47, 878	<0.0001***	2.59
Oecanthinae	47, 877	0.0389*	1.41
Pentatomidae	47, 878	<0.0001***	2.11
Parasitic Hymenoptera	47, 878	0.0308*	1.44
Reduviidae	47, 878	0.6161	0.93
Geocoris punctipes	47, 878	<0.0001***	4.19
All Beneficial Insects Combined	47, 877	<0.0001***	3.09

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level

2014 Sticky Card Trapping. Using the sticky card traps to survey occurrence of pollinating, beneficial, and plant-feeding insects in the four garden replicates, it was determined that long-legged flies (F: Dolichopodidae) were one of the most abundant pollinators collected ($P=<0.0001$, $F_{11,63}=5.33$) (Table A.6). Non-biting midges (F: Chironomidae) also dominated trap catches ($P=<0.0001$, $F_{11,63}=5.96$). Significance among "All Pollinators Combined" assemblage was determined, in which all pollinating insects captured on sticky traps were placed into a single group ($P=<0.0001$, $F_{11,63}=4.56$). Hover flies (F: Syrphidae) (P=0.1908), other flies (P=0.2358), and tumbling flower beetles (F: Mordellidae) (P=0.0816) also abundantly occurred. However, these groups were trapped in much lower numbers (Table A.6).

Beneficial and plant-feeding arthropods occurrence was also measured through sticky traps. Parasitic Hymenoptera ($P=0.0008$, $F_{11,63}=3.62$) were largely collected in the UGA Butterfly and Conservation Gardens whereas predatory ants (F: Formicidae) (P=0.1591), plant bugs (F: Miridae) (P=0.2097), and stink bugs (F: Pentatomidae) (P=0.4592) did not significantly occur (Table A.6). However, the "All Beneficial Insects Combined" assemblage in which all beneficial insects were combined into a single group was significant ($P=0.0020$, $F_{11,63}=3.25$) (Table A.6). The plant-feeding insect families consisting of Cicadellidae (leafhoppers and sharpshooters), Rhyparochromidae (seed bugs), Chrysomelidae (leaf beetles), Curculionidae (weevils), and Elateridae (click beetles) were not abundant in the four garden replicates (Table A.6). Likewise, "All Plant-Feeding Insects Combined" in which all plant-feeding arthropods surveyed were placed in a single group, was not significant (Table A.6).

Table A.6. Degrees of freedom, *P*-values, and *F*-values of pollinating, beneficial, and plant-feeding insect taxa collected from sticky traps over an eight-date period from June 3-August 5, 2014 at two trap heights from UGA Butterfly and Conservation Gardens (n=4) (Spalding, Co., GA).

Insect Taxa	Degrees of Freedom	P-Value	F-Value
Dolichopodidae	11, 63	<0.0001***	5.33
Syrphidae	11, 63	0.1908	1.42
Chironomidae	11, 63	<0.0001***	5.96
Other Flies	11, 63	0.2358	1.33
Mordellidae	11, 63	0.0816	1.78
All Pollinators Combined	11, 63	<0.0001***	4.56
Parasitic Hymenoptera	11, 63	0.0008***	3.62
Formicidae	11, 63	0.1591	1.50
Miridae	11, 63	0.2097	1.38
Pentatomidae	11, 63	0.4592	1.00
All Beneficial Insects Combined	11, 63	0.0020**	3.25
Cicadellidae	11, 63	0.2897	1.23
Rhyparochromidae	11, 63	0.4592	1.00
Chrysomelidae	11, 63	0.1470	1.54
Curculionidae	11, 63	0.1787	1.45
Elateridae	11, 63	0.7323	0.70

* indicates statistical significance at the P<0.05 level, ** indicates significance at the P<0.01 level, and *** indicates significance at the P<0.001 level