

Incidence and Abundance of Bees and Wasps (Hymenoptera) in Centipedegrass Lawns in Georgia¹

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Abstract We surveyed the occurrence of bees and wasps (Hymenoptera) in nine centipedegrass lawns in central and south Georgia in 2019 that had no prior exposure to insecticides. In each lawn, an area of 9.3 m² was marked and not mowed while the remainder of the lawn area was mowed regularly. When each centipedegrass lawn reached anthesis, pan traps filled with soapy water were placed in nonmowed and mowed areas of each lawn. After 3 d, trap contents were collected and transported to the laboratory for insect sorting and identification. Each lawn site was sampled 3–5 times. Of 173 total bees collected from the centipedegrass lawns, 79.2% were *Lasioglossum* spp. followed by 6.9% *Halictus* and 4% *Melissodes*. Only four *Bombus* spp. were collected, while other bees collected were *Augochlorella* spp., *Agapostemon* spp., *Megachile*, *Apis*, *Peponapis*, *Ceratina*, *Ptilothrix*, *Svastra*, and *Nomia* spp. Most of the *Lasioglossum* spp. were collected in August (48.6%) and September (26.6%). *Lasioglossum* spp. were sampled from all centipedegrass lawns; however, *Halictus* spp. and *Melissodes* spp. were collected only from one lawn in south Georgia. Captures were similar regardless of collection from mowed or nonmowed areas. Most of the bees were collected in pan traps that were blue or yellow in color; whereas, wasps were captured primarily in yellow-colored traps.

Key Words pollinators, parasitoids, predator, turfgrass

Turfgrass is ubiquitous and dominates most suburban and urban lands across the southeastern United States. In Georgia, the overall value of the turfgrass industry is US\$7.8 billion (Kane and Wolfe 2012), and the sod production industry is valued at approximately US\$1.12 billion (Farm Gate Value Report 2018). In addition to adding vital green cover and aesthetics to landscapes, turfgrass plays a pivotal role in preventing soil erosion and rainwater runoff (Armson et al. 2013), filtering or restricting movement of agricultural inputs such as fertilizers and pesticides to sensitive environments (Clark and Kenna 2010), improving air quality by absorbing airborne pollutants (Beard and Green 1994), and sequestering carbon (Mexia et al. 2018). Additionally, turfgrasses improve human health and well-being in their aesthetic beauty and as low-cost, safe recreational surfaces (Beard and Green

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1994, van den Bosch and Sang 2017). In the United States, lawns are typically maintained as green monocultures devoid of weeds or other flowering plants, and regularly trimmed and mowed. Turfgrasses are undoubtedly integral and valuable components of home, institutional, and recreational landscapes.

Turfgrass supports a diverse group of organisms, including microbes and invertebrates, that shape the allied ecosystems by linking food webs (Potter and Braman 1991). Also, it creates a transient environment for many arthropods, including pollinators, predators, and parasitoids (Lerman and Milam 2016). Although practitioners strive to maintain green spaces as impeccable as possible with one desired turfgrass, it is not unusual to see lawns with patches of weeds such as clover or dandelions. The flowers of these weeds often supplement nectar and pollen for foraging bees (Lerman and Milam 2016). Some lawns also have patches of exposed bare soil devoid of grass on the edges of lawn that often serve as habitat for ground-nesting bees (Cane 1991). Turfgrasses are often threatened by several pests that can reduce grass quality or cause eventual grass mortality (Potter and Braman 1991). In those situations, use of insecticides is inevitable to preserve the aesthetics, functions, or economic benefits of turfgrass. Adopting some strategies such as the selection of reduced-risk insecticides (e.g., chlorantraniliprole), appropriate formulation of the insecticides (e.g., granules), and cultural practices (e.g., mowing lawn before insecticide use) can considerably reduce the harmful effects of insecticides on foraging bees (Larson et al. 2013, 2014b).

Several species of bees utilize available floral resources in the green spaces (Lerman and Milam 2016) and landscapes around the green spaces in the urban and suburban ecosystems (Baldock et al. 2015, Frankie et al. 2005, McIntyre and Hostetler 2001, Ogilvie and Forrest 2017). Specific characteristics of the landscape such as man-made structures, woodlots, and agricultural lands define floral resource communities, which influence incidence and abundance of bees (Bennett and Lovell 2019, Matteson et al. 2008, Quistberg et al. 2016, Tommasi et al. 2004). Jones (2014) reported an active population of honey bees, *Apis mellifera* L., foraging the inflorescences of centipedegrass, with grass pollen subsequently recovered from those bees. This suggests that bees can play an important role in providing ecosystem services such as pollination in these habitats. In the southeastern United States, incidence and diversity of bees are not well documented from turfgrass. Thus, the objective of the current study was to record occurrence, abundance, and diversity of transient or foraging bees in turfgrass and, thus, document the pollinators present on centipedegrass lawns.

Materials and Methods

Study sites. This study was conducted on nine centipedegrass lawns (eight residential sites, one site on University of Georgia Griffin Campus) in several counties in central and southern Georgia between June and September 2019. Five of the lawns were in Tift Co., with one lawn each in Spalding, Pike, Coweta, and Upson counties (Fig. 1). The size of the sites ranged from 152 to 4,156 m², reflecting the variation in sizes of residential lawns seen in urban and suburban areas. The sites were separated by at least 1 km. None received any applications of

GA

Source: dynamaps.net (c)

Fig. 1. Counties in Georgia where bees and wasps were sampled from centipedegrass lawns.

pesticides (e.g., herbicides, fungicides, insecticides) prior to initiation of the study. Weeds growing in the study sites were minimal, with <10% of the surface area of each affected. We labeled the sites as C1, P1, U1, S1, T1, T2, T3, T4, and T5 to correspond to county and location (Table 1).

Table 1. Bees and wasps collected from nine centipedegrass lawns in Georgia in 2019.

Site ID	County	GPS Coordinates	Sweeping and Pan-Traps Removal Date	Size of Lawns (m ²)
C1	Coweta	33.389896, -84.697158	12, 26* Aug; 9 Sept	733
P1	Pike	33.187234, -84.270817	12, 29 Aug	4,156
U1	Upson	32.930416, -84.33918	12, 26 Aug; 9 Sept	702
S1	Spalding	33.267065, -84.292187	12, 26 Aug; 9 Sept	185
T1	Tift	31.465410, -83.485000	22 Jun; 6 Jul*; 9*, 23 Aug; 9 Sept	152
T2	Tift	31.465410, -83.551840	24 Jun; 8 Jul; 9*, 23 Aug; 9 Sept	1,446
T3	Tift	31.378210, -83.504310	9, 23* Aug; 9 Sept	939
T4	Tift	31.465060, -83.545140	9, 23 Aug; 9 Sept	1,647
T5	Tift	31.435700, -83.383360	9, 23 Aug; 9 Sept	2,335

* Dates where only wasps were sampled.

Sampling and evaluation. At each site, an area measuring 3.048 × 3.048 m (9.3 m²) was marked and not mowed for the duration of the study. Areas of each site not included in these marked areas were mowed, with the mowing interval varying among sites at the homeowner’s or field manager’s discretion. Sampling was initiated when the centipedegrass produced inflorescences (Table 1).

The beneficial insects were sampled from June to September 2019 using two methods: (1) pan traps (354.8-ml pans, Amscan, Elmsford, NY), and (2) standard sweep net samples. At each site, three pan traps each were placed in the mowed and nonmowed areas. The three pan traps in each area were yellow (“Yellow Sunshine”), blue (“Bright Royal”), and red (“Apple Red”) as described by the manufacturer. Those three pan traps were placed approximately 1 m apart in a triangular pattern within each area. Pan traps in mowed and nonmowed areas at each site were separated by approximately 6 m. At the sites in Spalding, Pike, Coweta, and Upson counties, pans were secured by nailing to the ground. Another pan of the same size and color was then placed over the first pan and secured using three binder clips. At the Tift Co. sites, the pans were secured to the ground with a 10.2-cm metal landscape fabric stake (Gardens Alive!, Lawrenceburg, IN), and the second pan was secured using two binder clips placed diagonally. Approximately 200 mL of dish soap solution (2 ml Dawn Dish Detergent [Procter & Gamble, Cincinnati, OH] in 3.8 L of water) was added to each trap. After 3 d, the contents in each trap was emptied into a plastic bag for transport to the laboratory for sorting and identification of insects. The contents of each trap at the Tift Co. sites were filtered through Great Value #2 Cone Coffee Filters (Walmart, Bentonville, AR).

Insects were then removed and placed in 50-ml centrifuge tubes containing 70% ethanol for eventual identification.

Sweep net samples also were collected between 0900 and 1500 hours (Eastern Daylight Time) in the mowed and nonmowed areas of each study site on the days that pan traps were emptied. Each sweep sampling pattern (10 sweeps in 180° arc) was conducted approximately 0.3 m apart in randomly selected directions within a designated area/site. Samples obtained were emptied into gallon-sized ziplock clear plastic bags (S.C. Johnson, Racine, WI) for transport to the laboratory, where they were temporarily stored in the laboratory freezer before subsequent identification of specimens. Sampling was not conducted simultaneously at all nine sites because centipedegrass did not flower synchronously at all sites (Table 1).

All the hymenopterans, except ants, were removed from the soap solution or frozen bags and placed into 70% ethyl alcohol. Hymenopterans, except parasitic wasps, were removed from the ethyl alcohol and pinned after drying with circulating air for 1–5 min. Pinned specimens were first sorted to bees and wasps. Bees were identified to genus using keys of Michener et al. (1994); wasps were not identified to genus level.

Statistical analysis. All the data were analyzed using the Statistical Analysis System (SAS Institute 2012). For analysis purposes, the site–date combination was considered as a replicate and only those site–date combinations that yielded bees and wasps were included in the analysis. The analysis was separately performed for bees and wasps. Within bees and wasps, analysis was performed by mowing status and pan-trap color. For mowing status analysis, paired Student's *t* test was conducted on the bee and wasp data where mowing status and site–date combination were the treatment and replication, respectively. Data were log-transformed ($\ln[x + 1]$) to establish homogeneity of variance using the PROC Univariate Procedure of SAS and analyzed using PROC TTEST procedure in SAS ($\alpha = 0.05$). For pan-trap color analysis, bee and wasp data were subjected to a one-way analysis of variance (ANOVA) after log-transformation ($\ln[x + 1]$), where pan-trap color and site–date combination were the treatment and replication, respectively. For ANOVA, data were subjected to PROC GLM and means were separated using the Tukey's honestly significant difference ($\alpha = 0.05$). The data obtained from the sweep samples were not analyzed because the number of bees and wasps captured was extremely low.

Results

Bee collections. Of the 173 bees collected from the centipedegrass lawns, 79.2% were *Lasioglossum* spp. followed by 6.9% *Halictus*, and 4% *Melissodes* (Table 2). Only four bumble bees, *Bombus* spp., were collected, while four specimens of *Augochlorella* spp. and two of *Agapostemon* spp. were collected. One specimen each of *Megachile*, *Apis*, *Peponapis*, *Ceratina*, *Ptilothrix*, *Svastra*, and *Nomia* spp. was captured. Although *Lasioglossum* spp. were collected in all months in which sampling was conducted, 48.6% of them were captured in August followed by 26.6% in September (Fig. 2A). Similarly, *Melissodes* spp. were captured during all 4 mo of sampling. *Halictus* spp. were not collected in September, and other bees

Table 2. Genera of bees collected from nine centipedegrass lawns in Georgia in 2019.

Family	Genus	Number of Bees Captured
Megachilidae	<i>Megachile</i>	1
Apidae	<i>Apis</i>	1
Apidae	<i>Peponapis</i>	1
Apidae	<i>Ceratina</i>	1
Apidae	<i>Bombus</i>	4
Apidae	<i>Melissodes</i>	7
Apidae	<i>Ptilothrix</i>	1
Apidae	<i>Svastra</i>	1
Halictidae	<i>Agapostemon</i>	2
Halictidae	<i>Augochlorella</i>	4
Halictidae	<i>Nomia</i>	1
Halictidae	<i>Halictus</i>	12
Halictidae	<i>Lasioglossum</i>	137

were collected only in one or two samples. *Lasioglossum* spp. were sampled from all centipedegrass lawns (Fig. 2B). Most of the *Halictus* spp. and *Melissodes* spp. were collected from one lawn in Tift Co. *Bombus* spp. and *Augochlorella* spp. were collected from three sites, and the remainder of the bees were collected from one site only.

Effect of mowing and trap color. Pan-trap captures of bees were similar between mowed and nonmowed areas ($t=1.4$; $df=48$; $P=0.166$; Fig. 3). Similarly, *Lasioglossum* spp. ($t=1.6$; $df=48$; $P=0.101$; Fig. 4A) and non-*Lasioglossum* spp. ($t=-0.4$; $df=48$; $P=0.684$; Fig. 4B) captured were not significantly different between mowed and nonmowed areas. Captures of wasps (e.g., Sphecidae, Vespidae, Pompilidae) were also not significantly different between mowed and nonmowed areas ($t=-1.1$; $df=50$; $P=0.257$; Fig. 3).

Significantly greater numbers of bees were captured in the blue and yellow traps than in the red traps ($F=23.4$; $df=2, 46$; $P<0.001$; Fig. 5). Similarly, the number of *Lasioglossum* spp. collected was significantly greater in the blue and yellow traps than in red traps ($F=20.9$; $df=2, 46$; $P<0.001$; Fig. 6A). The number of non-*Lasioglossum* spp. captured in the blue traps was significantly greater than in the red traps ($F=5.7$; $df=2, 46$; $P=0.006$; Fig. 6B). However, the number of non-*Lasioglossum* spp. captured in either blue and yellow traps or yellow and red traps was not significantly different. Among trap colors, the yellow-colored traps captured significantly more wasps ($F=35.6$; $df=2, 68$; $P<0.001$) as compared with the blue- or red-colored traps (Fig. 5).

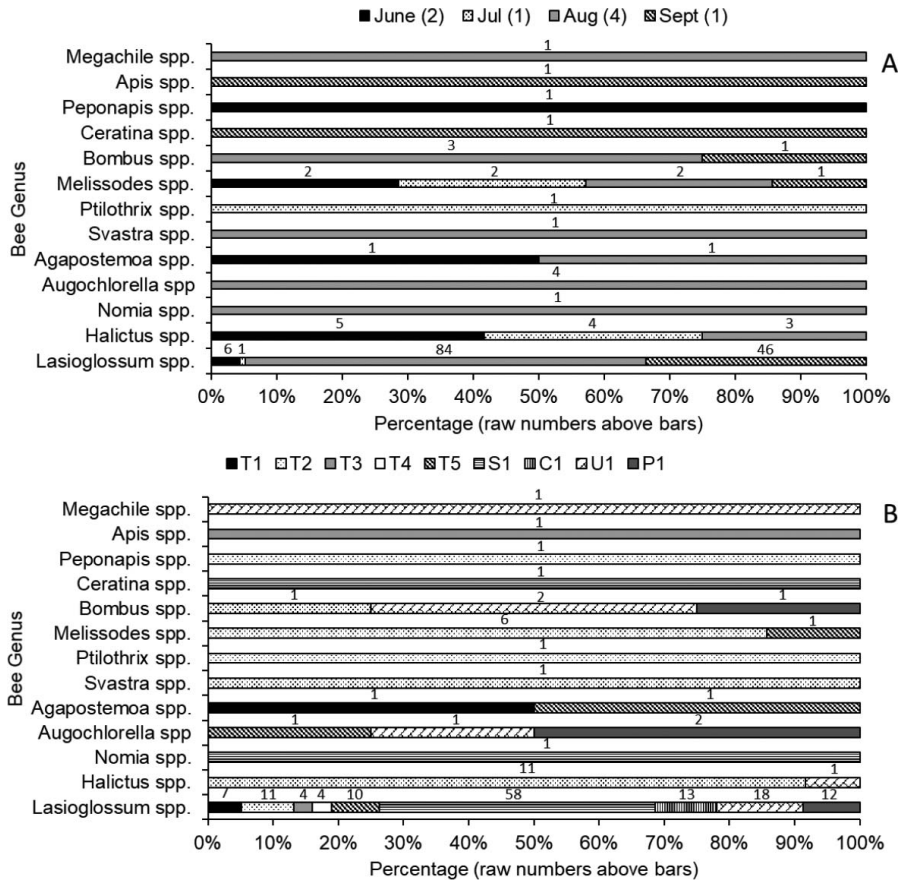


Fig. 2. Percentage of bees captured from centipedegrass lawns by sample date (A) and location (B). The numbers in parentheses indicate the number of sampling dates included in each month.

Discussion

In a pursuit of increasing the bee activity in lawns, we sought to understand the incidence of foraging bees in centipedegrass lawns. A diversity of bee genera were collected from the nine centipedegrass lawns surveyed in our study. *Lasioglossum* spp. were the most abundant bee genus collected from the centipedegrass lawns. These results agree with studies conducted in urban and suburban lawns in southern Connecticut (Zarrillo et al. 2016), New York (Fetridge et al. 2008), and Massachusetts (Lerman and Milam 2016). Similarly, *Halictus* spp. were the second highest in abundance in this and the previous study of Lerman and Milam (2016). Although low in numbers collected, *Augochlorella* spp., *Agapostemon* spp., *Melissodes* spp., *Bombus* spp., *Megachile* sp., *Apis* sp., *Peponapis* sp., *Ceratina* sp., *Ptilothrix* sp., *Svastra* sp., and *Nomia* sp. were also collected from the

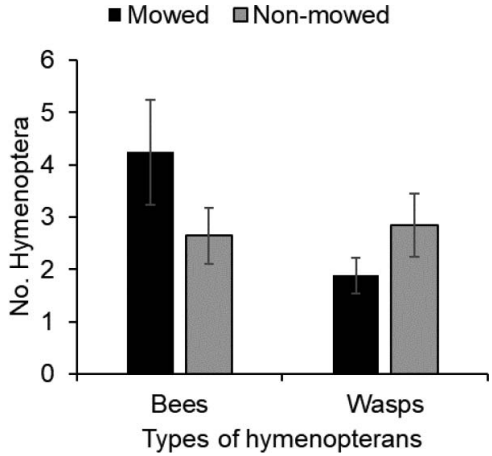


Fig. 3. Mean (\pm SE) bees and wasps collected from mowed and nonmowed areas of the centipedegrass lawns. Pairs of bars, within the hymenopteran type, with no symbols are not significantly different (Student's *t* test, $\alpha = 0.05$).

centipedegrass lawns. This suggests that diverse species of bees are residing in close proximity to lawns and foraging in and around the lawns seeking floral resources, which is consistent with previous studies of Tommasi et al. (2004), Lerman and Milam (2016), Jones (2014), Larson et al. (2014a), and Lerman et al. (2018).

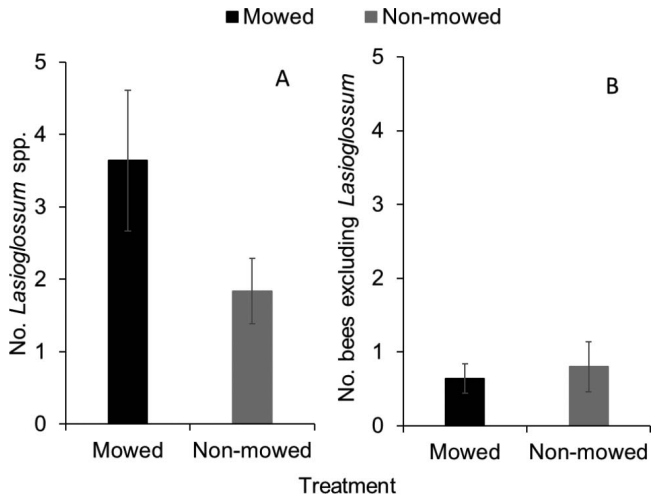


Fig. 4. Mean (\pm SE) *Lasioglossum* spp. (A) and non-*Lasioglossum* spp. (B) collected from mowed and nonmowed areas of the centipedegrass lawns. Pairs of bars, within the hymenopteran type, with no symbols are not significantly different (Student's *t* test, $\alpha = 0.05$).

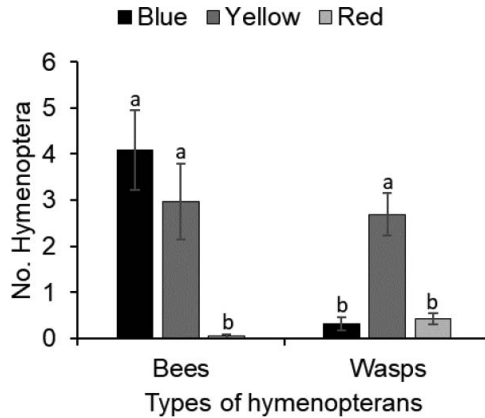


Fig. 5. Mean (\pm SE) bees and wasps collected from various colored pan-traps treatments. Treatments with the same letters, within each hymenopteran type, are not significantly different (Tukey's honestly significant difference test at $\alpha = 0.05$).

Most of the bees collected were ground-nesting bees rather than cavity dwellers. *Lasioglossum* spp., *Halictus* spp., *Ptilothrix* sp., *Svastra* sp., and *Nomia* sp. are solitary ground-nesting bees (Cane 1995, Hannan et al. 2013, Rust 1980). *Lasioglossum* spp. were collected from all sites in the current study, suggesting that

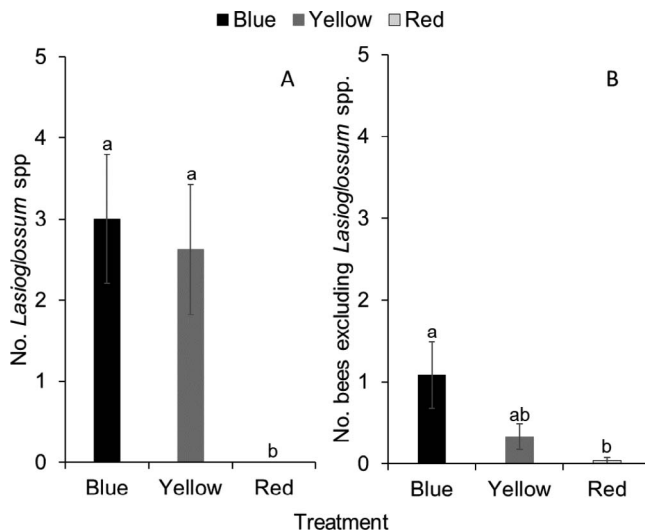


Fig. 6. Mean (\pm SE) *Lasioglossum* spp. (A) and non-*Lasioglossum* spp. (B) collected from various colored pan-traps treatments. Treatments with the same letters, within each hymenopteran type, are not significantly different (Tukey's honestly significant difference test at $\alpha = 0.05$).

they can inhabit different soil types, including the sandy soils characteristic of the Tift Co. sites. In general, ground-nesting bees prefer nesting spots that are in well-drained soils with adequate access to sunlight (Cane 1991, Potts and Willmer 1997). In the current study, most of the *Halictus* spp. were collected from one site in Tift Co. (T2), which has a well-drained, sandy-textured soil. Most halictids forage on flowers of multiple plant species, consuming nectar and carrying pollen on the tibia and femur of their hind legs to provision eggs in ground nests (Michener 2007). *Melissodes* spp., mostly solitary bees, are specialists on members of the Asteraceae plant family and have been reported from residential yards (Lerman and Milam 2016). In Georgia, 17 species of bumble bees are reported as active from March to October (Schlueter 2019, Schlueter and Stewart 2015). Increases in urbanization and decreases in floral resources have been postulated as the cause of the worldwide decline in the abundance of bumble bees (Ahrné et al. 2009, Glaum et al. 2017, Goulson et al. 2008). Also in our study, we collected one squash bee, *Peponapis* sp., and a small carpenter bee, *Ceratina* sp., in different pan traps, suggesting that there could be potential cross movement of bees seeking floral resources in residential lawns. *Peponapis* sp. are specialized on pollinating cucurbit plants (Rozen and Ayala 1987), and *Ceratina* sp. is not a ground-nesting bee, but instead is a cavity-nesting bee that usually uses broken plant stems for nesting (Rau 1928). There are reports of *Svastra* sp. using lawns for nesting (Cane 1995).

Bee captures did not increase in nonmowed areas of the centipedegrass lawn relative to mowed areas. The anticipation was that the inflorescences of centipedegrass in the nonmowed areas of the lawn would enhance activity of foraging bees and that would be reflected with increased pan-trap captures. In a previous survey, honey bees were found foraging on flowers of centipedegrass, with pollen subsequently recovered from their bodies (Jones 2014). Similar bee captures in mowed versus nonmowed areas might be due to a number of factors. The colored pan traps could have attracted most of the transient bees so that pan-trap captures reflected activity of both foraging and transient bees rather than those specifically visiting the flowers of centipedegrass. Second, both mowed and nonmowed areas of centipedegrass may have produced inflorescence due to the mowing frequency and the production of inflorescences at mowing height as determined by the homeowner or manager of the turfgrass at the sites. And, the foraging behavior of bees on inflorescences of grass species is still not known.

The results showed that the color of the pan trap influenced trap captures. Bees were caught primarily in blue and yellow pan traps. This is consistent with the findings of Hall (2016), who reported that most bees collected in that study were from blue- and yellow-colored pan traps.

Our study further demonstrated that wasps in centipedegrass lawns have diverse ecological habits. Some are predators while others are parasitic on other arthropods in the turfgrass system. Parasitic wasps are common in turfgrass ecosystems (Frank et al. 1995, Joseph and Braman 2011, Rogers and Potter 2004), and predaceous wasps (e.g., Vespidae, Sphecidae, Crabronidae) provide pest management services in lawns, although they can be nuisance pests in certain situations (Sumner et al. 2018).

Floral resources are critical to supporting bee diversity in residential landscapes (Baldock et al. 2015, Bennett and Lovell 2019, Larson et al. 2014a, Lerman and Milam 2016, Mach and Potter 2018, Matteson et al. 2008, McIntyre and Hostetler

2001, Ogilvie and Forrest 2017, Quistberg et al. 2016, Tommasi et al. 2004). Our study further showed that diverse bee genera transit over centipedegrass lawns. Among the ground-nesting bees, *Lasioglossum* spp. and *Halictus* spp. were most common genera. Other studies showed that the flowers of weeds in lawns can provide supplemental nectar and pollen sources for foraging bees (Larson et al. 2014a, Lerman and Milam 2016, Lerman et al. 2018). Our study failed to detect a difference in bee captures in mowed versus nonmowed areas of centipedegrass. Additional research is warranted, perhaps with refined techniques, to document foraging behavior of bees on the inflorescences of turfgrass species.

In summary, bees belonging to 13 genera have been collected from centipedegrass lawns at various times. Homeowners and landscape managers, therefore, should apply insecticides conservatively as they may prove toxic to foraging bees in the lawns (Gels et al. 2002). Furthermore, homeowners and landscape managers also should be aware of the activity of foraging bees in the lawns before determining mowing frequency in the southeastern United States in order to best protect pollinators. Proper insecticide selection, formulation, and cultural practices would reduce exposure of bees and wasps to pesticides (Joseph and Buske 2017; Larson et al. 2013, 2014b). If pesticide use is essential in lawns, it is critical that applicators stringently follow pesticide labels before use to help conserve the diversity of foraging and ground-nesting bees and wasps in lawns. Future studies are required to determine the attractiveness of the centipedegrass inflorescences in comparison with other flowering plants to foraging bees in urban or suburban landscapes. Similarly, more studies are warranted to understand the foraging behavior and time spent on centipedegrass inflorescences, as well as the quality of grass pollen to nourish developing larvae in bee nests.

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