School and Community Garden Pollinator Census: A Pilot Project in Georgia[1]

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Abstract During 2017 and 2018, gardeners at 36 locations across 21 Georgia counties volunteered to be part of the Georgia Pollinator Census project. The goals of the project were to generate a snapshot of pollinator population data while educating gardeners about the importance of pollinators and other beneficial insects and assisting schools with science, technology, engineering, art, and math programming. Effective insect identification training and on-going support were crucial parts of this citizen science project. Insect counting was conducted in September and October on an aster species and another plant species chosen by the participants. Twenty-eight plant taxa were chosen by participants to be frequently visited by pollinators. Analysis of the data indicates a higher number of sightings of bumble bees, *Bombus* spp. Latrelle (Hymenoptera: Apidae); honey bees, *Apis mellifera* L. (Hymenoptera: Apidae), and wasps (Hymenoptera: Vespidae) in rural areas and a higher number of sightings of carpenter bees, *Xylocopa* spp. Latrelle (Hymenoptera: Apidae); flies (Diptera); and “other insects” (e.g., those that did not fall into any of the other seven categories) in urban areas. We also saw an increase in entomological interest among the participants as well as an increase in insect knowledge. This pilot project was used to refine criteria for a larger state-wide census.

Key Words pollinator conservation, citizen science, floral resources

Floral resources are a consistent predictor of pollinator health and offer conservation opportunities in urban environments (Hall et al. 2016 and references cited therein). Urban settings, however, have unique conservation challenges. Bee abundance, for example, was shown to decline 41% with each 1°C of urban warming, and bee abundance declined with urban warming regardless of floral density (Hamblin et al. 2018). Negative attitudes toward insects can hinder their conservation but can be overcome with exposure and education (Harris and Braman 2016). In fact, media attention has fostered increased public awareness of pollinator loss and offers an opportunity for public support of conservation efforts (Schönfelder and Bogner 2017). Urban community engagement offers tremendous opportunity for enhanced pollinator conservation (Griffin and Braman 2017). Pollinator health should be a main consideration when developing integrated pest management plans (Biddinger and Rajotte 2015). Plants that mutually support

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pollinators and other beneficial insects can be identified and deployed as appropriate for various urban and traditional agricultural settings (Braman and Quick 2018, Harris et al. 2016).

The use of school gardens, including pollinator gardens, in curriculum instruction is increasing among Georgia schools (Food Well Alliance 2015). School gardens are often being used as a pathway to the Georgia Department of Education Science, Technology, Engineering, Art, and Math (STEAM) School Certification. This creates an opportunity to educate teachers and students about pollinators in a way that would assist schools in the pursuit of STEAM certification. Learning to identify native pollinators can increase interest in pollinator conservation among citizens, especially youth (Chawla and Cushing 2007). The Georgia Pollinator Census Pilot Project was designed to (a) evaluate pollinator plant choice on a native aster, *Symphyotrichum ericoides* (L.) G.L. Nesom, and an additional plant chosen by volunteer participants; (b) educate citizens on pollinator protection; and (c) determine the potential for a greatly expanded citizen science pollinator census.

Citizen science is a useful, low-cost tool for research often requiring only a website to disseminate project information to participants and to upload collected data (Birkin and Goulson 2015). In some instances, the citizen scientists pay to be a part of the program. For example, Project FeederWatch (Cornell University, Cornell, NY) began in 1900 and is a joint effort between the Cornell Lab of Ornithology and Bird Studies Canada for which citizens count and identify birds. From November 2015 to April 2016, 22,082 bird-watchers across North American reported on 7 million birds through Project FeederWatch (Cornell Lab of Ornithology & Bird Studies Canada 2016). The Coastal Observation and Seabird Survey Team showed that participation in place-based citizen science linked to local or global issues can lead to a measurable change in individual and collective action (Haywood et al. 2016).

Materials and Methods

Volunteer recruitment. In March 2017, enrollment opened for the Georgia Pollinator Census project through a webpage, with a limit of 50 gardens. Within 36 h, volunteers representing 50 gardens in 25 Georgia counties enrolled with a waiting list. Some of these gardens were school gardens and others were community or public gardens. The 2010 Federal Census definitions of urban and rural were used to designate sites as urban or rural (Branch 2012). Each garden was provided with 3 *Symphyotrichum ericoides* var. prostrata ‘Snow Flurry’ plants in 0.9-L containers grown by a local nursery. This low-growing aster, native to much of North America, blooms throughout Georgia in the fall. Each counting group also was provided with an insect identification and collection kit (BioQuip, Compton, CA) that contained an insect net, collection jars, pins, and a magnifier. A project manual (Insect Counting and Identification Guide) was developed as an online printable reference for all counters. In late April and early May 2017, B.G. visited all 50 gardens and delivered the asters and insect kits. Gardeners were instructed on planting and caring for the asters during the summer. The project was designed to support instructional goals (Miczajka et al. 2015) and was repeated during 2018.

Training and use of social media. Project preparation included developing instructional materials to guide participants in data collection and construction of a web-based platform to support data entry statewide. Providing tools for self-efficacy in pollinator counting for students predicts a likelihood of becoming more involved in this type of science as adults (Saribas et al. 2014). It was important for data collectors to feel comfortable with their task and have the tools to make useful counts (Kremen et al. 2011). We hosted online training sessions and provided an insect identification and counting guide that the gardeners could download and print for reference. The insect guide reinforced our training session. It also contained a bee anatomy diagram, an example counting plan, and a printable counting worksheet. The Georgia Pollinator Census Facebook website was created to provide gardeners information and a way for them to interact with each other. We encouraged participants to share photos of their pollinator gardens and their counting sessions. The Facebook site was one way to offer on-going support during the project. On Tuesdays, B.G. posted a short insect biology lesson as #TaxonomyTuesdays. Short videos on topics (e.g., how to effectively use the insect net) were shared.

Data collection. All participants were asked to count pollinator visitation for 15 min per session on their asters and on an additional plant that the participants felt was attractive to pollinators. Participants counted twice a week for 4 weeks during September and October each year. They were asked to count the number of carpenter bees, *Xylocopa* spp. Latrelle (Hymenoptera: Apidae); bumble bees, *Bombus* spp. Latrelle (Hymenoptera: Apidae); honey bees, *Apis mellifera* L. (Hymenoptera: Apidae); small bees (Hymenoptera); flies (Diptera); wasps (Hymenoptera: Vespidae); butterflies (Lepidoptera); and "other insects" on one 'Snow Flurry' aster and the plant of their choice. Counters were not asked to consider plant size or maturity when choosing a plant for this study. We did not try to standardize the plants among counting sites. Participants uploaded their counting data onto the dedicated website. Participants also were given the opportunity to evaluate the program through an online survey that was distributed in November.

Statistical analyses. Data were analyzed using a generalized mixed model using SAS software (SAS Institute 2017). For urban and rural comparisons, data were analyzed using a two-tailed test of proportions. When appropriate, treatment means were separated using Tukey's honestly significant difference method. Means separation technique was done by using the least significant difference test following a significant analysis of variance.

Results

Thirty-six gardens from 21 counties across the state ultimately participated and uploaded data with a total of 309 counting periods. Twenty-eight plant taxa, in addition to the provided 'Snow Flurry' aster, were reported by participants as frequently visited by pollinators (Fig. 1). Plants that participants reported pollinator visitation on (Tables 1 and 2) included heather aster (*Symphyotrichum ericoides* (L.) G.L. Nesom; designated plant no. 1), butterfly weed (*Asclepias tuberosa* L.; no. 2), common boneset (*Eupatorium boneset* L.; no. 3), autumn joy sedum (*Sedum telephium* L. 'Autumn Joy'; no. 4), cardinal flower (*Lobelia cardinalis* L.; no. 5),

Table 1. Mean (±SE) bees observed per plant taxa per 15-min observation period in a citizen science project.*

Plant No.**	Year	Total Bees	Carpenter Bees	Bumble Bees	Honey Bees	Small Bees
3	2017	60.33 (19.84) a	2.67 (0.58) cd	17.00 (5.84) a	38.11 (14.57) a	2.56 (0.69) bc
	2018	31.33 (7.87) b	8.56 (1.84) a	12.44 (5.15) a	6.00 (3.39) b	4.33 (1.9) bc
23	2017	24.40 (5.68) b	13.70 (3.19) a	4.00 (1.98) bc	3.30 (1.32) bc	3.40 (1.07) bc
	2018	3.0 (0.50) c	0.09 (0.09) c	0.27 (0.14) b	1.0 (0.56) bc	1.63 (0.31) c
19	2017	23.67 (7.88) b	1.67 (1.67) cd	7.33 (2.33) b	4.00 (3.51) bc	10.67 (2.96) a
	2018	NA	NA	NA	NA	NA
15	2017	15.40 (1.75) bc	7.60 (1.96) b	5.20 (1.59) b	1.00 (0.63) bcd	1.60 (0.67) cd
	2018	NA	NA	NA	NA	NA
13	2017	9.40 (2.18) bcd	1.20 (0.58) cd	2.80 (0.73) bcd	2.00 (0.54) bc	3.40 (0.75) ab
	2018	NA	NA	NA	NA	NA
20	2017	9.17 (3.96) bcd	0 (0) d	5.50 (2.29) b	0 (0) bcd	3.67 (1.74) ab
	2018	NA	NA	NA	NA	NA
4	2017	8.15 (2.89) bcd	4.38 (2.01) c	0.15 (0.10) cd	1.92 (0.92) bc	1.69 (0.35) cd
NA	2018	NA	NA	NA	NA	NA
27	2017	8.00 (4.00) bc	0.50 (0.50) d	1.00 (1.00) b	2.00 (2.00) b	4.50 (3.50) abc
	2018	NA	NA	NA	NA	NA
25	2017	6.57 (1.98) bcd	0 (0) d	1.14 (0.70) bcd	2.14 (1.67) bc	3.29 (1.72) bc
	2018	NA	NA	NA	NA	NA

Table 1. Continued.

Plant No.**	Year	Total Bees	Carpenter Bees	Bumble Bees	Honey Bees	Small Bees
9	2017	6.14 (1.51) bcd	1.27 (0.34) cd	0.23 (0.15) bcd	0.73 (0.34) bcd	3.91 (1.20) bc
	2018	20.14 (3.56)c	0.43 (0.29) c	0.14 (0.14) b	1.14 (0.46) bc	9.21 (3.31) b
6	2017	6.12 (1.67) bcd	0.18 (0.18) d	2.52 (1.23) b	0 (0) bcd	3.41 (1.07) ab
	2018	11.00 (3.78) c	3.00 (1.47) bc	4.25 (1.70) b	1.50 (0.95) bc	2.25 (0.85) c
18	2017	6.06 (1.25) bcd	0.69 (0.44) cd	1.31 (0.33) bcd	0 (0) bcd	4.06 (1.38) bc
	2018	12.09 (2.78) c	0.64 (0.28) c	0.36 (0.15) b	1.45 (0.43) bc	5.63 (2.68) bc
12	2017	5.77 (2.49) bcd	0.62 (0.37) cd	0.08 (0.08) bcd	0 (0) bcd	5.08 (2.42) ab
	2018	NA	NA	NA	NA	NA
7	2017	5.29 (1.15) bcd	0.57 (0.30) cd	2.71 (1.02) bcd	0.86 (0.34) bc	1.14 (0.40) bc
	2018	NA	NA	NA	NA	NA
10	2017	3.93 (1.02) bcd	0.85 (0.35) cd	1.56 (0.74) bcd	0.78 (0.26) bcd	0.74 (0.32) bc
	2018	3.80 (2.12) c	2.80 (2.31) bc	0.40 (0.40) b	0 (0) c	0.6 (0.4) c
17	2017	3.50 (1.50) cde	0 (0) d	0 (0) bcd	0 (0) cd	3.50 (1.50) abc
	2018	NA	NA	NA	NA	NA
8	2017	2.75 (0.75) bcd	1.00 (0.41) d	0.75 (0.48) bcd	0 (0) bcd	1.00 (0) bc
	2018	42.71 (7.55) a	0.71 (0.36) c	3.57 (1.50) b	21.71 (5.08) a	16.71 (3.33) a
1	2017	2.25 (0.33) bcd	0.03 (0.01) d	0.23 (0.07) bcd	0.23 (0.08) bcd	1.75 (0.29) bc
	2018	NA	NA	NA	NA	NA

Table 1. Continued.

Plant No.**	Year	Total Bees	Carpenter Bees	Bumble Bees	Honey Bees	Small Bees
22	2017	1.88 (0.64) bcd	0.50 (0.38) cd	0.86 (0.64) bcd	0 (0) bcd	0.50 (0.33) cd
	2018	NA	NA	NA	NA	NA
5	2017	1.25 (0.90) bcd	0 (0) d	1.25 (0.90) bcd	0 (0) bcd	0 (0) d
	2018	NA	NA	NA	NA	NA
2	2017	1.00 (0) e	0 (0) d	0 (0) d	0 (0) d	1.00 (0) bc
	2018	7.87 (4.06) c	6.50 (4.20) ab	0 (0) b	0 (0) c	1.37 (1.24) c
14	2017	1.00 (0.33) de	0.13 (0.13) d	0 (0) bcd	0 (0) bcd	0.88 (0.35) bcd
	2018	NA	NA	NA	NA	NA
24	2017	0.50 (3.78) bcd	0.38 (0.38) d	0 (0) bcd	0.13 (0.13) bcd	0 (0) d
	2018	NA	NA	NA	NA	NA
11	2017	0.33 (0.21) bcd	0 (0) d	0 (0) bcd	0 (0) bc	0.33 (0.21) d
	2018	NA	NA	NA	NA	NA
21	2017	0.17 (0.17) bcde	0 (0) d	0 (0) bcd	0 (0) bcd	0.17 (0.17) d
	2018	NA	NA	NA	NA	NA
16	2017	0 (0) cde	0 (0) cd	0 (0) bcd	0 (0) bcd	0 (0)
	2018	NA	NA	NA	NA	NA
27	2017	NA	NA	NA	NA	NA
	2018	5.0 (0) c	4.0 (0) abc	1.0 (0) b	0 (0) c	0 (0) c

Table 1. Continued.

Plant No.**	Year	Total Bees	Carpenter Bees	Bumble Bees	Honey Bees	Small Bees
28	2017	NA	NA	NA	NA	NA
	2018	12.25 (1.1)c	3.5 (0.85) bc	3.0 (1.08) b	0.25 (0.25) c	5.5 (0.64) bc
29	2017	NA	NA	NA	NA	NA
	2018	1.67 (0.33) c	0.67 (0.66) c	0.33 (0.33) c	0 (0) c	0 (0) c

* Means within columns followed by the same lowercase letter are not significantly different ($P = 0.05$). Means separation technique was done by least significant difference test following a significant analysis of variance. NA Not Applicable as data were collected.
** Plant number corresponds to list presented in the text results with tables referenced.

Table 2. Mean (±SE) insects observed per plant taxa per 15-min observation period in a citizen science project.*

Plant No.**	Year	Total Pollinators	Wasps	Flies	Butterflies	Other Insects
3	2017	85.33 (26.97) a	20.89 (7.05) a	2.22 (0.74) bc	1.89 (0.54) a	2.22 (0.72) bc
	2018		12.33 (2.44) b	2.84 (1.06) bcd	1.00 (0.35) c	2.67 (0.83) bcd
23	2017	48.00 (9.23) b	4.70 (1.42) b	17.30 (5.53) a	1.60 (0.73) a	10.4 (3.11) a
	2018		0.18 (0.12) c	0.36 (0.20) c	0.82 (0.29) c	0.36 (0.28) c
19	2017	36.67 (9.56) b	4.67 (0.33) b	3.00 (1.00) abc	5.33 (1.45) a	5.67 (3.18)
	2018	NA	NA	NA	NA	NA
15	2017	25.8 (2.58) bc	1.00 (0.45) bc	4.40 (2.23) bc	5.00 (0.55) a	6.00 (1.52) ab
	2018	NA	NA	NA	NA	NA
13	2017	15.60 (2.87) bc	2.80 (1.07) bc	2.60 (0.51) abc	0.80 (0.20) a	1.00 (0.45) ab
	2018	NA	NA	NA	NA	NA
20	2017	14.83 (5.73) bc	0.17 (0.17) bc	1.67 (0.67) bc	8.83 (2.33) a	1.00 (0.45) ab
	2018	NA	NA	NA	NA	NA
4	2017	12.92 (3.76) c	3.08 (0.83) bc	0.92 (0.18) bc	0.77 (0.47) a	1.77 (0.57) ab
	2018	NA	NA	NA	NA	NA
27	2017	13.50 (5.50) bc	2.00 (1.00) b	3.00 (1.00) abc	0.50 (0.50) a	5.50 (0.50) ab
	2018	NA	NA	NA	NA	NA
25	2017	7.00 (2.25) c	0 (0) bc	0 (0) bc	0.43 (0.43) a	0 (0) ab
	2018	NA	NA	NA	NA	NA

Table 2. Continued.

Plant No.**	Year	Total Pollinators	Wasps	Flies	Butterflies	Other Insects
9	2017	13.05 (2.10) c	0.86 (0.26) bc	0.73 (0.28) bc	5.32 (0.95) a	3.23 (2.25) ab
	2018		1.57 (0.48) c	0.64 (0.29) cd	9.37 (4.33) a	2.5 (0.34) bcd
6	2017	15.24 (3.31) c	0.53 (0.26) bc ab	4.82 (1.58) abc	3.76 (1.61) a	7.00 (1.71) ab
	2018		4.0 (0.91)c	1.46 (0.20) cd	6.25 (0.86) ab	6.08 (3.78) bc
18	2017	7.69 (1.41) c	0.13 (0.09) bc	0.81 (0.33) bc	0.69 (0.31) a	1.25 (0.68) ab
	2018		1.27 (0.33) c	0.36 (0.28) c	2.65 (1.76) bc	7.27 (2.66) b
12	2017	7.85 (2.84) c	1.51 (0.56) bc	0.62 (0.46) bc	0.31 (0.17) a	6.62 (2.31) a
	2018	NA	NA	NA	NA	NA
7	2017	7.29 (1.19) c	0 (0) bc	0.57 (0.43) bc	1.43 (0.37) a	0.42 (0.20) ab
	2018	NA	NA	NA	NA	NA
10	2017	10.11 (2.02)	0.59 (0.14) bc	1.89 (0.80) bc	3.70 (0.97) a	2.15 (1.20) ab
	2018		0.88 (0.37) c	4.00 (0.99) bc	4.33 (0.97) abc	2.65 (0.20) bcd
17	2017	16.5 (4.50) cd	0 (0) bc	10.00 (5.00) ab	3.00 (1.00) a	5.50 (0.50) ab
	2018	NA	NA	NA	NA	NA
8	2017	7.00 (2.42)	3.75 (1.44) bc	0.50 (0.50) bc	0 (0) a	0.50 (0.50) ab
	2018		16.71 (3.33) a	9.29 (3.24) a	0.28 (0.11) c	32.29 (2.80) a
1	2017	4.24 (0.50) cd	0.34 (0.07) bc	1.41 (0.24) bc	0.25 (0.05) a	1.46 (0.23) ab
	2018	NA	NA	NA	NA	NA

Table 2. Continued.

Plant No.**	Year	Total Pollinators	Wasps	Flies	Butterflies	Other Insects
22	2017	11.50 (2.41) c	2.75 (1.19) bc	5.88 (1.84) ab	1.00 (0.27) a	3.25 (1.08) ab
	2018	NA	NA	NA	NA	NA
5	2017	3.25 (1.70) c	0 (0) bc	0 (0) bc	2.00 (1.02) a	2.25 (1.45) ab
	2018	NA	NA	NA	NA	NA
2	2017	4.50 (2.50) d	0 (0) c	3.50 (2.50) abc	0 (0) a	4.00 (3.00) ab
	2018		0.5 (0.38) c	1.5 (0.92) cd	1.87 (0.71)bc	5.62 (2.44) bc
14	2017	7.00 (1.69) cd	4.63 (1.45) b	1.25 (0.37) bc	0.13 (0.13) a	1.00 (0.27) ab
	2018	NA	NA	NA	NA	NA
24	2017	1.63 (0.53) cd	0 (0) bc	0.75 (0.49) bc	0.38 (0.18) a	2.75 (0.41) ab
	2018	NA	NA	NA	NA	NA
11	2017	2.00 (0.52) cd	1.15 (0.56) bc	0.62 (0.46) bc	0.31 (0.17) a	6.62 (2.31) b
	2018	NA	NA	NA	NA	NA
21	2017	0.50 (0.34) cd	0 (0) bc	0 (0) c	0.33 (0.33) a	0 (0) ab
	2018	NA	NA	NA	NA	NA
16	2017	0 (-) cd	0 (-) bc	0 (-)bc	1.00 (-) a	0 (-) ab
	2018	NA	NA	NA	NA	NA
27	2017	NA	NA	NA	NA	NA
	2018		0 (0) c	0 (0) d	1.0 (0) c	0 (0) d

Table 2. Continued.

Plant No.**	Year	Total Pollinators	Wasps	Flies	Butterflies	Other Insects
28	2017	NA	NA	NA	NA	NA
	2018		0.33 (0.33) c	1.75 (1.73) cd	1.50 (0.17) bc	0 (0) d
29	2017	NA	NA	NA	NA	NA
	2018		0.33 (0.33) c	5.33 (3.55) b	2.67 (2.29) b	0 (0) d

* Means within columns followed by the same lowercase letter are not significantly different ($P = 0.05$). Means separation technique was done by least significant difference test following a significant analysis of variance.
** Plant number corresponds to list presented in the text results with tables referenced.

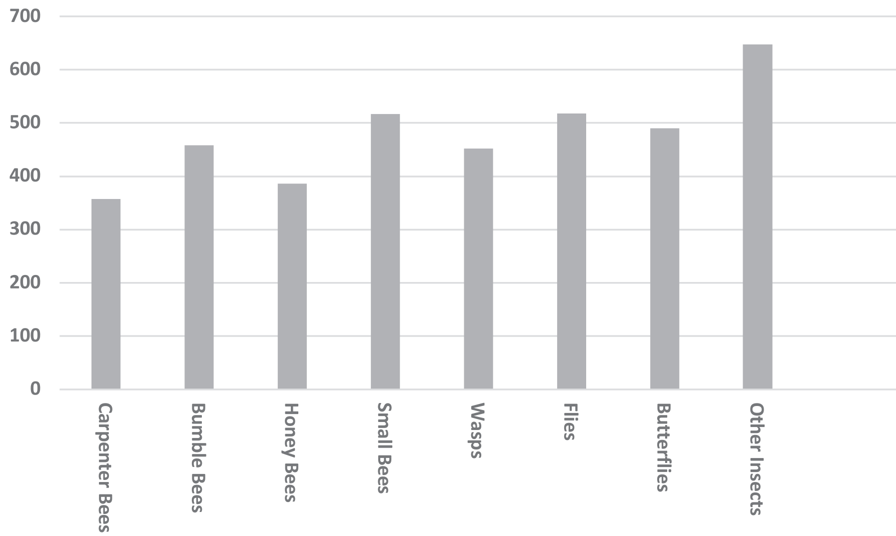

Fig. 1. Number of insects counted during 15-min observation periods on participant-identified pollinator plant.

lantana (*Lantana camara* L.; no. 6), Mexican sunflower (*Tithonia rotundifolia* (Mill.) S.F. Blake; no. 7), mint (*Mentha* spp. L.; no. 8), zinnia (*Zinnia elegans* L.; no. 9), butterfly bush (*Buddleia davidii* Franch.; no. 10), purple aster (*Symphyotrichum carolinianum* (Walter) Wunderlin & B.F. Hansen; no. 11), black-eyed Susan (*Rudbeckia hirta* L.; no. 12), chocolate mint (*Mentha X piperita* L. 'Chocolate Mint'; no. 13), mountain mint (*Pycnanthemum muticum* (Michx.) Pers.; no. 14), black and blue salvia (*Salvia guaranitica* A. St.-Hil. ex Benth. 'Black & Blue'; no. 15), Gerber daisy (*Gerbera jamesonii* Bolus ex Hook. F.; no. 16), white clover (*Trifolium repens* L.; no. 17), French marigold (*Tagetes erecta* L.; no. 18), tickseed (*Coreopsis lanceolate* L.; no. 19), orange cosmos (*Cosmos sulphureus* Cav.; no. 20), garden snapdragon (*Antirrhinum majus* L.; no. 21), prairie coneflower (*Ratibida columnifera* (Nutt.) Woot. & Standl.; no. 22), basil (*Ocimum basilicum* L.; no. 23), purple coneflower (*Echinacea purpurea* (L.) Moench; no. 24), butter daisy (*Melampodium paludosum* Kunth; no. 25), goldenrod (*Solidago* spp. L.; no. 26), sage (*Salvia officinalis* L.; no. 27), coreopsis (*Coreopsis* sp. L.; no. 28), and abelia (*Abelia X grandiflora* (Rovelli ex André) Rehder; no. 29).

Of all insect visitors on 'Snow Flurry' asters across the state, 38% were small bees (Fig. 2) and 23% were flies. Carpenter bees, honey bees, bumblebees, butterflies, and wasps also were observed visiting this plant, but less frequently. Plant taxa significantly affected the number of total bees, carpenter bees, bumble bees, and small bees (Table 3), as did year of study, site, and date. The plants most often visited by total number of bees were common boneset during 2017 and mint during 2018 (Table 1). Carpenter bees mostly visited basil and common boneset. Bumble bees mostly visited common boneset. Honey bees were most common on boneset and mint. Small bees were equally common on many plants, including tickseed, black-eyed Susan, goldenrod, French marigold, and zinnia (Table 1).

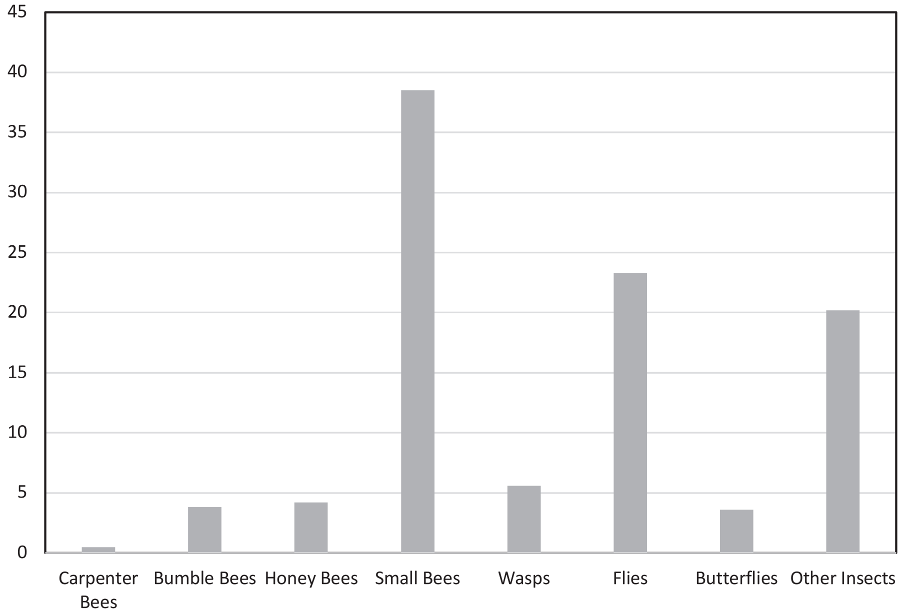

Fig. 2. Percentage of total insects in each pollinator category observed during 15-min observation periods on 'Snow Flurry' asters.

Total pollinators, wasps, flies, butterflies, and other insects also were significantly influenced by plant taxa (Table 4). Common boneset was most visited by total number of pollinators observed (Table 2). Wasps were more commonly observed on common boneset, whereas mint, white clover, prairie coneflower, black and blue salvia, and lantana were most frequently visited by flies. Orange cosmos, tickseed, zinnia, black and blue salvia, and lantana were highly visited by butterflies. Plants most visited by "other insects" were basil, lantana, black-eyed Susan, purple aster, black and blue salvia, and mint (Table 2).

Table 3. Analysis of fixed effects on number of bees observed during 15 min on various plant taxa in a citizen science project.

		Total Bees		Carpenter Bees		Bumble Bees		Honey Bees		Small Bees	
Effect	**df**	***F***	***P***	***F***	***P***	***F***	***P***	***F***	***P***	***F***	***P***
Year	1	19.90	$<$0.0001	6.85	0.01	1.40	0.24	5.80	0.02	9.57	0.003
Site	18	9.26	$<$0.0001	1.86	0.02	2.73	0.001	9.24	$<$0.0001	11.24	$<$0.0001
Date	13	3.86	$<$0.0001	1.00	0.46	2.53	0.005	2.29	2.29	2.15	0.02
Plant	7	5.47	$<$0.0001	3.85	0.001	3.66	0.001	0.56	0.56	2.21	0.04

Table 4. Analysis of fixed effects on number of insects observed during 15 min on various plant taxa in a citizen science project.

		Total Pollinators		Wasps		Flies		Butterflies		Other Insects	
Effect	**df**	***F***	***P***	***F***	***P***	***F***	***P***	***F***	***P***	***F***	***P***
Year	1			18.45	<0.0001	1.66	0.20	13.16	0.0005	5.72	0.019
Site	18	2.04	0.0007	12.77	<0.0001	5.48	<0.0001	5.40	<0.0001	17.88	<0.0001
Date	13	3.39	0.0053	1.96	0.0327	0.78	0.67	2.06	0.023	1.87	0.044
Plant	7	10.54	<0.0001	6.21	>0.0001	2.45	0.02	2.51	<0.024	2.56	0.02

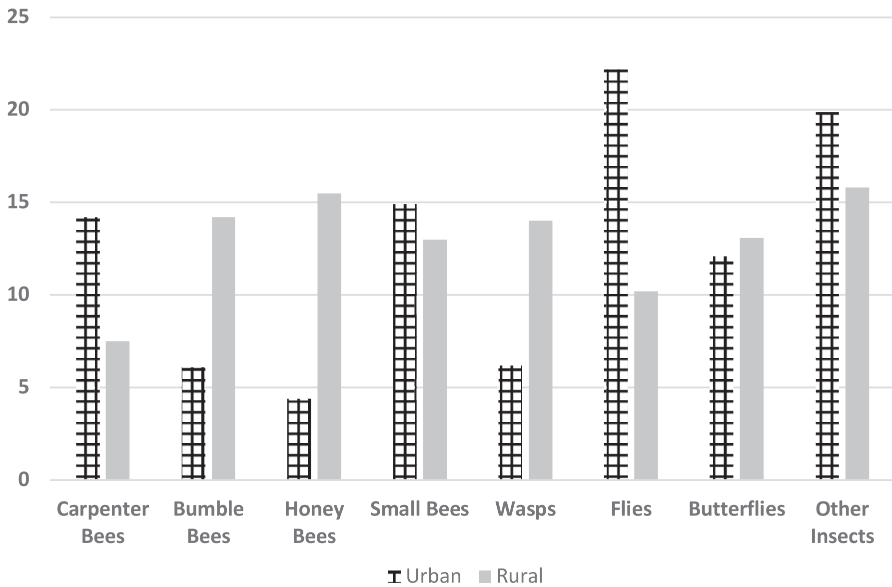

Fig. 3. Percentage of total insects in each pollinator category observed during 15-min observation periods on participant-identified pollinator plant in urban or rural gardens.

All categories of insects were present in both urban and rural gardens (Fig. 3). The percentages of insect visits from small bees and butterflies were similar between urban and rural sites. Urban sites, however, reported more carpenter bees, flies, and other insects. Rural areas reported more bumble bees, honey bees, and wasps.

Twenty-three gardens completed the online evaluation. Online training and support met the needs of the participants, with 86% of the respondents stating that before the training, they were “not confident at all” or “somewhat confident” in insect identification. After the training, 100% of the respondents said that they were “somewhat confident” or “very confident” in the insect identification.

The project was designed to be useful for teachers who are using STEAM programs in their classrooms and for those who were working toward the Georgia Department of Education STEAM certifications. Data from the evaluations sent to educators in the program showed 23% indicated that they used the project in STEAM programming, and 8% indicated that they used the project in their efforts toward STEAM certification. Of the teacher respondents, 84% reported that they used the project in their classroom curriculum, and 100% indicated that they used the resources provided in their classroom instruction. The project also changed the students’ perceptions of insects and entomology, with 94% of respondents indicating that students want to be involved in similar projects, were no longer afraid of insects, had an increased interest in entomology, and had a greater awareness of pollinator importance.

Discussion

More than 24 plant species were reported as frequently visited by pollinators in this 2-yr study. Selection of those plants other than the 'Snow Flurry' aster mandated by the study introduced some uncontrolled variability in reporting, that is, the same plant species and varieties were not used at all observation sites. Those plants likely varied in total size or in bloom area over the observation sites. We also recognize that some counters may show some unconscious bias or feel more confident in their insect identification skills or that counters are recording each time an insect lands on their favorite pollinator plant, thereby actually tallying insect visits as opposed to insect counts.

Even with these factors, a number of important findings were learned in our study. The results suggest that 'Snow Flurry' aster could be a landscape plant choice for homeowners who want to have a pollinator-friendly landscape for which a late-blooming ground cover design element is needed. Pollinating insects clearly frequent this plant. Carpenter bees were found more often in urban gardens; yet, of the top 5 plants most visited by carpenter bees, only 1 was located in urban gardens, whereas the other 4 were found only in the rural gardens. Plant availability cannot explain these study results. Urban areas may have more available wood, possibly in man-made wooden structures, for carpenter bee nesting. Flies and other insects also were seen in higher numbers in urban gardens. Of the top 5 plants most visited by flies, 2 were only in urban gardens, 1 was only in the rural gardens, and 2 were in both. Of the top plants most visited by pollinators in the other insect category, 2 were only in urban gardens, 2 were only in rural gardens, and 1 was in both.

Bumble bees, wasps, and honey bees were found more often in rural gardens. The top 5 plants most visited by bumble bees were only in the rural gardens. Four of 5 plants most visited by wasps were only in rural gardens. This plant availability may explain the differences found between rural and urban bumble bee and wasp populations. However, rural areas may have more bare soil as opposed to concrete or asphalt for ground-nesting bees. Some cavity-nesting bees have a low thermal tolerance, and the heat islands in urban areas may have an impact on the bumble bee populations (Hamblin et al. 2017). Other bees need natural cavities for nesting, for example, dried flower stems. Many bees and wasps nest in the ground or around trees as well. It is possible that these requirements were not as well met in the urban environments of this study. Four of the 5 plant types most visited by honey bees were in the rural gardens only. However, we do not know which gardens had honey bee hives in close proximity.

Other problems of note included loss of the aster plants before counts were conducted in September. Participants reported that asters were stolen or died from neglect or mowing. Hurricane Irma also traversed eastern Georgia in 2017 during the census time, destroying some pollinator gardens and delaying counts in others. Also, unfortunately, some participant groups lost interest over the duration of the project.

Of note, however, was the enthusiasm Georgians had for the initiative. Teachers with no entomological background were excited to guide their students through the basics of insect identification that this study taught. A new insect habitat was created for groups so that they were able to participate in the project. Community gardeners rallied around the project and participated together. Also, we were able to develop criteria that provided some data while making it possible for citizens to participate.

Future studies focusing on an expanded, state-wide census will incorporate lessons learned from this pilot study. The state-wide census will be concentrated on 2 days, namely, a Friday and a Saturday, to keep the counters interested in participating. Increased insect identification and counting training will be conducted in-person and online by adding collaborative partners to expand the project outreach. An expanded use of technology and social media for educational purposes will occur to meet the needs of all participants, especially educators and their students. Questions asked during data collection will be expanded to learn the proximity of honey bees to the plants used in counting. Finally, an additional goal of increasing sustainable pollinator habitat suitable for Georgia will be added to the project goals.

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