Native Bee (Hymenoptera: Apoidea) Abundance and Diversity in North Georgia Apple Orchards throughout the 2010 Growing Season (March to October)

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Abstract - Bees play a key role in agriculture, directly affecting the production of over one-third of the human food supply. *Apis mellifera* (Honey Bee), the chief pollinator used in commercial agriculture, has been in decline. Reliance on a single species for the pollination of a significant portion of commercial agriculture can be dangerous. One alternative to using Honey Bees as the main commercial pollinator is native bees. In this study, we document native bee species diversity and abundance throughout the 2010 growing season (March through October) at 4 North Georgia *Malus domestica* (Apple) orchards. The 4 study sites included 2 large-scale orchards (Mercier Orchards and Hillside Orchards) and 2 small-scale orchards (Mountain View Orchards and Tiger Mountain Orchards). A comprehensive sampling methodology using pan-traps, vane-traps, malaise traps, and sweep-netting was performed at each orchard on 8 separate collection days. A total of 1817 bees were identified to species. These bees comprised 128 species in 28 genera in 5 families. Several native bee species were quite common and widespread at all 4 orchards. These native bee species included: *Andrena crataegi, A. perplexa, Lasioglossum imitatum, L. pilosum,* and *Xylocopa virginica* (Eastern Carpenter Bee). *Andrena crataegi* was identified as the best native bee candidate for Apple pollination in North Georgia due to its abundance, wide-spread distribution in Georgia Apple orchards, and its life-history characteristics.

Introduction

It is estimated that 35% of global food production is dependent on animal pollination. Insects, mainly bees, are the main animal pollinator of almost every fruit, nut, and vegetable crop (Klein et al. 2007). *Apis mellifera* (Honey Bee) is the most important insect pollinator for the majority of agriculture crops; the yields of some crops decrease by more than 90% when Honey Bees are not present. In the United States alone, bees contribute roughly $15 billion in pollination services each year (Morse and Calderone 2000).

Reliance on a single insect species for the pollination of over 1/3 of the human food supply can be dangerous. Indeed, this situation is especially precarious considering that Honey Bee populations are in decline, thus putting the global food supply at risk. In the United States, there was a sharp decline in managed Honey Bee colonies from 4 million in the 1970s to 2.4 million in 2005 (USDA National Agriculture Service, 1977, 2006). In 2006, the situation worsened with a significant increase in Honey Bee losses (30–90% of colonies). These losses were documented particularly in the East Coast of the United States, due to the phenomenon labeled

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Manuscript Editor: Richard Brown

Colony Collapse Disorder (CCD; Cox-Foster et al. 2007, Johnson 2007, Oldroyd 2007). The reduced availability of Honey Bee colonies has increased food production costs and lowered potential crop yields. Alternative pollination strategies that are less dependent on the Honey Bee must be developed in order to ensure long-term sustainability of insect pollinated crops.

The best pollination alternatives to Honey Bees are the native bees already present in the local environment. There are over 17,000 bee species in the world (Michener 2007). With nearly 3500 bee species in North America alone, the diversity of different forms (size, pubescence, etc.), pollination strategies, and behaviors (early spring emergence, prolonged daily foraging, shorter inter-flower travel, etc.) provide an effective native bee pollinator for every fruit, nut, and vegetable crop (Chagnon et al. 1993; Greenleaf and Kremen 2006; Kremen et al. 2002, 2004).

It is estimated that native bees already annually contribute \$3 billion to US agriculture (Losey and Vaughan 2006). In addition, native bees exhibit much greater pollination efficiency compared to Honey Bees. In *Malus domestica* Borkhausen (Apple) pollination, for example, one female *Osmia cornifrons* (Radoszkowski) (Mason Bee) is estimated to pollinate 2450 blooms per day, compared to 80 per day by a Honey Bee (Parker et al. 1987). Winfree et al. (2008) found that native bees were able to provide full pollination services to most farms in heterogeneous landscapes.

Every region, even every crop, has its own characteristic group of native bee pollinators. Data concerning regional make-ups of these native pollinator-guilds are severely lacking, which is one reason that farmers have relied so heavily on Honey Bees. In fact, across the continent, available information on the role of pollination by native bees is spotty at best (Cane and Tepedino 2001, Committee on the Status of Pollinators in North America 2007). Therefore, research is needed to determine which native bees are present in a given region. Crop specific studies are needed to identify appropriate target native bees in order for farmers to provide the best habitat enrichments and resources to boost target native bee abundances.

In the following study, we have documented the native bee species diversity and abundance in Apple orchards in northern Georgia. With over 2000 bees sampled, including 128 different bee species, a clearer picture of the native bee resources in northern Georgia has been obtained. We hypothesize that native bees can supplement or even replace the Honey Bees in Apple pollination in Georgia.

Field-site Description

The study sampled 4 Apple orchards within the apple-growing region of northern Georgia. We sampled each site 8 times from March to October. The 2 western sites (Mercier Orchards and Mountain View Orchards) straddle the Georgia–Tennessee border. The 2 eastern sites (Hillside Orchards and Tiger Mountain Orchards) are located just north of the Chattahoochee National Forest. The Eastern Continental Divide separates the 2 eastern sites from the 2 western sites. In the West, Mercier Orchards (Blue Ridge, GA), the largest Apple orchard in Georgia, is a large-scale industrial operation with more than 150,000 trees on over 80 ha (200 ac). In contrast, Mountain View Orchards (McCaysville, GA) is a small-scale, family-style orchard with less than 1000 trees. In the East, Tiger Mountain Orchards (Tiger, GA) is also a family-style operation with just over 1000 trees. Hillside Orchards (Tiger, GA) is a moderate-scale industrial orchard with ~40,000 trees. In the United States, 96% of all Apple orchards are operated on less than 80 ha (200 acres), with small-scale orchards being quite common (USDA National Agriculture Service 2009). All 4 orchards are located within similar surroundings of mixed suburban, agricultural, and forested environments. Hillside Orchards has the largest surrounding natural area (Chattahoochee National Forest) with expansive undeveloped forest tracts. Mercier Orchards, due to its large size, has the least surrounding natural area.

Methods

Sample plot design

The sample plot was designed to collect native bees (Apoidea) in a standardized, comparable manner between all sites and all seasonal periods. This plot design is a derivative of the USGS Standard Bee Inventory Plot (LeBuhn et al. 2003). The sample plot was 100 x 100 m and incorporated both passive and active sampling methods. Passive traps included: (1) 7 sets of UV-yellow, UV-blue, and white level-pan traps; (2) 6 sets of UV-yellow, UV-blue, and white elevated-pan traps; (3) 6 sets of UV-yellow and UV-blue vane-traps; and (4) 2 ground-level malaise traps. Whereas the pan and vane traps are known to be attractive to bees, malaise traps are thought to intercept the flight of bees passing through the area. The 13 sets of pan traps alternated between level and elevated. We placed the level-pan traps directly upon the ground and spaced roughly 1 m apart, and set the elevated pans 0.91 m (3 ft) off the ground (on average, the height of the lowest available Apple blossoms during bloom). Likewise, we hung the vane-traps from Apple trees at an elevation of 0.91–1.52 m (3–5 ft). The pans and vanes were consistently placed in the exact same positions every sample day, and denoted by flags, while the malaise trap placements were randomized. Active sampling methods consisted of an hour of timed-transect sweep-netting. Sweep-net sampling involved walking up and down the Apple tree rows for an hour at a constant pace during the afternoon (between 2–4 pm) while sweeping constantly. We swept the Apple flowers during bloom, while at other time periods we swept the wildflowers within the orchard. We performed all of the sampling methods (bowls, vanes, malaise, and sweep-netting) at each orchard during the 8 sampling days from March to October.

Collection-device specifics

The pan-traps consisted of 15.24-cm (6-inch) diameter, 800-ml (24-oz) plastic bowls. We painted each bowl with UV-yellow, UV-blue, or white primer spray paint. Yellow bowls received 2 coats of UV-yellow spray paint (Rust-Oleum Fluorescent Yellow) after a coating of plastic primer (Rust-Oleum Ultra Cover Primer). Blue bowls received 2 coats of UV-blue spray paint (Ace Hardware Fluorescent Blue) after a coating of plastic primer. We sprayed white bowls with 2 coats of the white primer. The platforms upon which elevated pans were placed consisted of a 0.91-m (3-ft) section of 2.54-cm (1-inch) PVC pipe with a 0.91-m (3-ft) plank of 2 x 4 wood attached on top. We fitted each elevated bowl with a magnet, which corresponded to a large-washer glued to the piece of wood, allowing secure attachment of the bowls in the field.

The vane traps (Oak Stump Farms Trap; www.springstar.net) came in blue and yellow colors. We sprayed the vanes portion of each trap with either UV-blue or UV-yellow paint in order to increase its sampling effectiveness.

The malaise traps were of the Townes designed (www.bioquip.com, catalog number 2868). No modifications were made to these traps.

Sampling protocol

During each survey day, 2 sites were sampled. We placed the collection devices within the same pre-flagged areas prior to 10:30 am and retrieved them after 8 to 10 hours. Sampling occurred on 8 days per site during the growing season, beginning March 15, two weeks prior to the first Apple blooms, and ending around the last week of October. Following the first survey day prior to the onset of bloom, subsequent sampling occurred weekly during the Apple bloom until May 19 and then occurred once a month for the remainder of the growing season.

After collection, we pooled all specimens captured within similar devices. For instance, we placed within a single vial containing ethanol all collections for a single sample day, per site, from the UV-Blue level-pans.

Specimen identification

We took the bees stored in ethanol to the research lab. We first sorted each raw field sample vial into broad groups (non-pollinators, pollinating Diptera, Apoidea, etc.). We then identified the bees wereto the species level or, in rare cases, to species' groups (especially for the *Dialictus* and *Nomada*). The main species identification tools and references used to identify the bees were "Discover Life" website (Pickering and Ascher 2012), Bees of the World (Michener 2007), Michener et al. (1994), Pascarella's (2012) Bees of Florida, and Gibb's (2010, 2011) revision of the metallic *Lasioglossum* (*Dialictus*). After identification, we databased, catalogued, labeled, and stored the bees.

Damaged specimens that could not be identified were not included in the study. Difficult and rare bee species identifications were checked and verified by Sam Droege (US Native Bee Lab, US Geological Survey, Patuxent Research Center, Patuxent, VA). The University of Georgia Collection of Arthropods (UGA Department of Entomology), USGS Native Bee collection, and the Penn State University Frost Museum were also used in specimen identification verifications.

Results

During the 2010 growing season, we collected a total of 2025 bees within the 4 North Georgia Apple orchards (8 collections per site, spanning March to October). Of those initial 2025 bees sampled, 208 were unidentifiable beyond genus. The

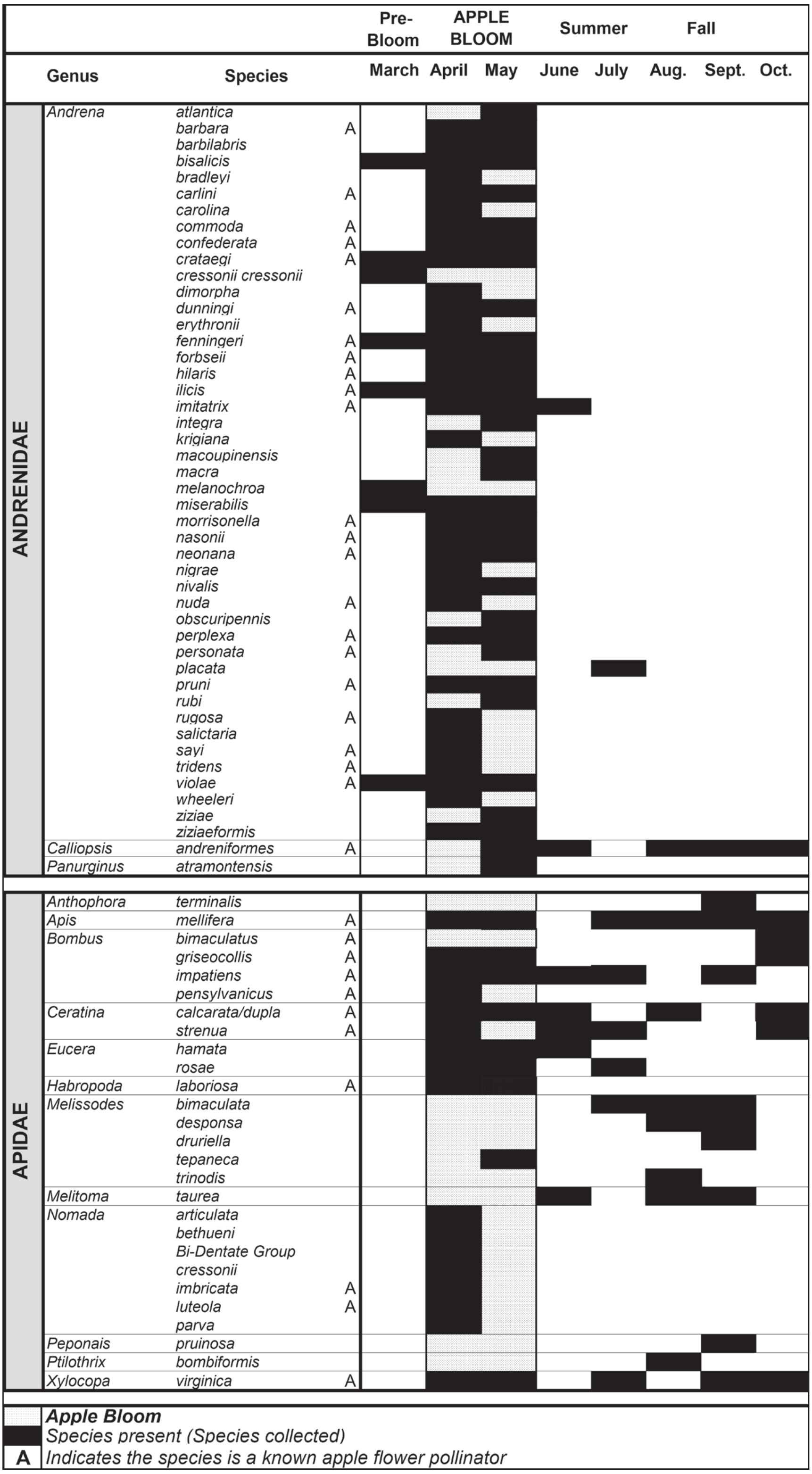

Figure 1. Temporal occurrence of native Andrenidae and Apidae collected at 4 North Georgia Apple orchards during the 2010 growing season (March–October). The Apple bloom occurred during most of April and the beginning of May. Black shading represent bee species collected during a given month.

remaining 1817 bees were identified to one of 128 species within 30 genera (Figs. 1, 2; Appendix 1).

Collection methods

Pan traps collected 587 bees (32.3%), vane traps collected 172 bees (9.5%), malaise traps collected 285 bees (15.7%), and sweep-netting collected 773 bees

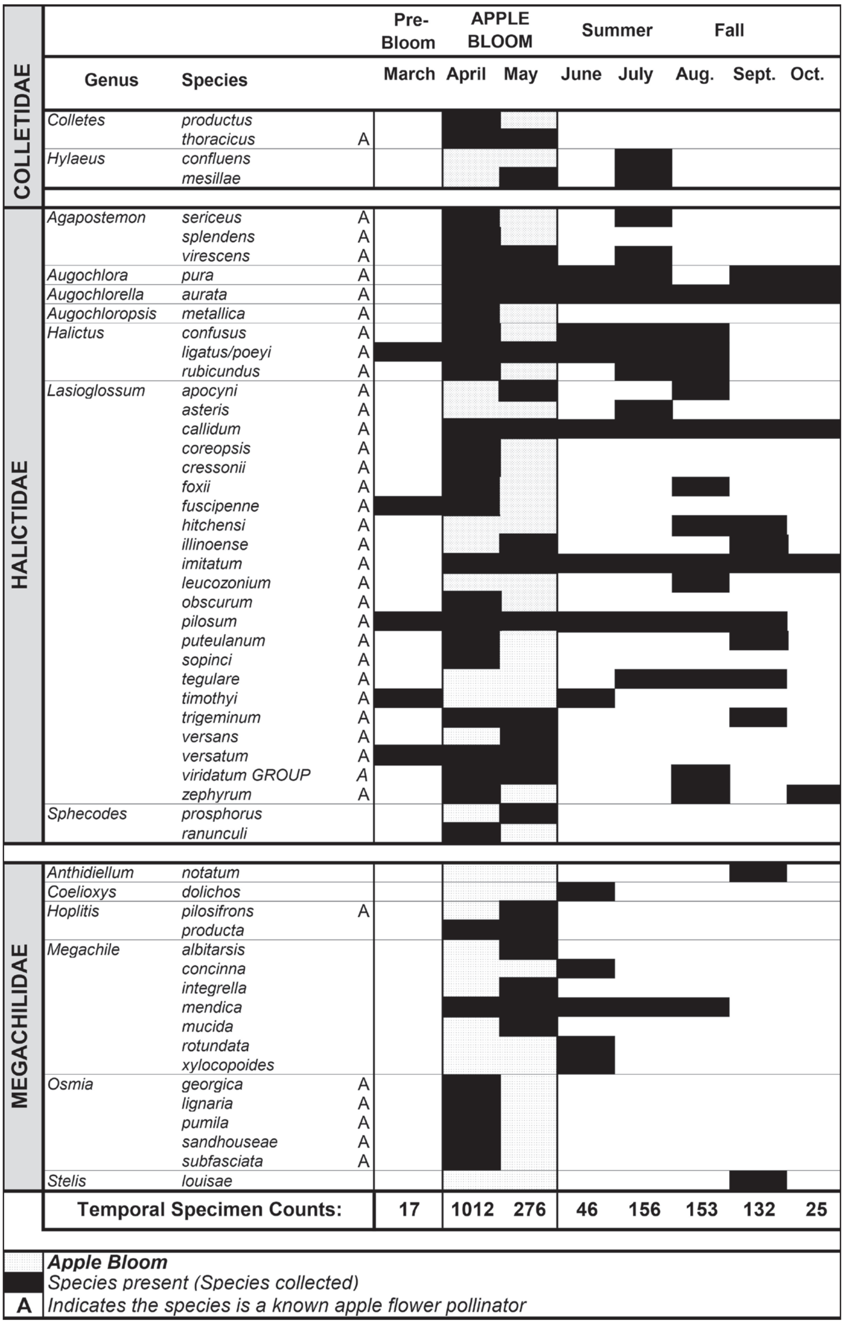

Figure 2. Temporal occurrence of native Colletidae, Halictidae, and Megachilidae collected at 4 North Georgia Apple orchards during the 2010 growing season (March–October). Total temporal specimen counts are also shown. The Apple bloom occurred during most of April and the beginning of May. Black shading represent bee species collected during a given month.

(42.5%) (Appendix 1). Of the 128 species, pan traps collected 93 (72.7%), vane traps collected 43 (33.6%), malaise traps collected 54 (42.2%), and active sweep-netting collected 72 (56.3%). Each trap also collected unique species that were collected only by that specific trap type: 25 in pan traps, 6 in vane traps, 11 in malaise traps, and 20 by sweep-netting. In total, 62 of 128 (48.4%) species were collected only by one type of sampling method.

Bee abundance and diversity

There were 128 Honey Bees (7.0%) and 1689 native bees (93.0%) collected at the 4 orchards during 2010. Honey Bee abundance within sites was strongly related to the number of Honey Bee colonies placed in each orchard. *Andrena crataegi* was the most abundant native bee species collected in the apple orchards, with 563 specimens or 31.0% of all bees caught. The next 2 most abundant native bee species were *Lasioglossum* (*Dialictus*) *imitatum* (227; 12.5%) and *L.* (*D.*) *pilosum* (94; 5.2%).

The specific abundance and diversity results for each family of bees are found in Appendix 1. The breakdown of native bee abundances and diversity findings for each family in the study gives insight into which species of bees were best represented in Georgia's apple orchards.

Family Andrenidae. The andrenids were the most abundant of all the Apoidea, with 844 specimens (46.5% of bees in all samples) collected. The specimens accounted for 3 genera and 47 species (36.4% of the season's diversity). Andrenids represented roughly 1 out of every 2 bees sampled. *Andrena crataegi* was by far the most notable of this group, totaling 563 of the 1817 bees caught.

The andrenids were also strongly periodic, with the majority of the specimen catches falling between the beginning of sampling (March 15) and the cessation of the Apple bloom (May 19). The only andrenids to be collected after the Apple bloom were single specimens of *A. imitatrix* and *A. placata* collected on June 19 and July 17, respectively.

Family Halictidae. The halictids were the second most abundant family, with 622 specimens (34.2% of all bees) collected. The specimens represented 7 genera and 33 species (25.6% of the season's diversity). This family was composed of 3 major groups: (1) the green sweat bees (*Agapostemon, Augochlora, Augochlorella,* and *Augochloropsis*); (2) the genus *Halictus;* and (3) the speciose genus *Lasioglossum*. The most common bees of this latter group included the tiny species *L. imitatum* (227; 12.5%) and the gold-toned *L. pilosum* (94; 5.2%).

Family Apidae. The apids were the third most abundant family, with 311 specimens (17.1% of all bees) collected. The specimens represented 12 genera and 28 species (21.7% of the season's diversity). The 311 bees were comprised of 183 (58.2%) native bees and 128 (41.2%) Honey Bees. The 183 native bees account for 10% of the 2010 abundance totals. The most abundant native apid was the large *Xylocopa virginica* (Eastern Carpenter Bee), accounting for 61 specimens (3.3%).

Family Megachilidae. The megachilids were the fourth most abundant family, with 32 specimens (1.8% of all bees) collected. The specimens represented 6 genera and 17 species (13.1% of the season's diversity). The most common megachilid was the species *Megachile mendica* with 7 specimens.

Family Colletidae. The colletids were the least abundant family, with 8 specimens (0.4% of all bees) collected. The specimens represented 2 genera and 4 species (3.1% of the season's diversity).

Common native species richness and abundance

Several species of bees were common at most orchards (Tables 1, 2). While not necessarily the most abundant species by site, these common species are likely to be found throughout North Georgia in similar habitats (agricultural orchards) and provide insight into the dominant species one can assume might be present in agricultural areas.

Table 1 shows the common species between all sites, while Table 2 lists the common species found at the sites excluding Mercier Orchards. Both tables are included because Mercier's species abundance and diversity was significantly lower than the other 3 orchards. The particularly low species richness at Mercier Orchards removed many common species. Fifteen species were found to be present at all 4 sites, together accounting for 1247 of the total 1817 bees sampled that year. Each species is known from earlier studies to be rather common throughout the Eastern Seaboard, especially species like *A. crataegi, B. impatiens, L. imitatum, L. pilosum*, and *X. virginica* (Gardner and Ascher 2006).

Rare native species richness and abundance

Rarely collected species are also important to consider when examining species richness. In this paper, we defined rare species as those for which we collected <3

Table 1. Bee species occurring at all 4 North Georgia Apple orchards sampled during the 2010 season, March to October.

Family/genus	Species	Hillside	Mercier	Mt View	Tiger	Total
ANDRENIDAE						
Andrena	*crataegi*	76	3	414	71	564
Andrena	*fenningeri*	4	1	2	8	15
Andrena	*imitatrix*	1	2	7	3	13
Andrena	*violae*	5	7	8	4	24
Calliopsis	*andreniformes*	2	1	3	3	9
APIDAE						
Apis	*mellifera*	55	32	25	15	127
Bombus	*impatiens*	3	4	4	9	20
Ceratina	*calcarata/dupla*	3	2	2	7	14
Xylocopa	*virginica*	17	1	16	27	61
HALICTIDAE						
Agapostemon	*sericeus*	1	1	5	2	9
Agapostemon	*virescens*	7	3	18	4	32
Halictus	*ligatus/poeyi*	8	1	3	3	15
Lasioglossum	*callidum*	2	1	4	18	25
Lasioglossum	*imitatum*	28	3	182	12	225
Lasioglossum	*pilosum*	10	1	16	67	94
Total	Abundance	222	63	709	253	1247

specimens during the sampling season. Generally in terrestrial ecosystems, it is expected that most insect species in a community will be rarely collected during any one sampling season, and most of these rare species will experience high-species turnover on a year-to-year basis.

Of the 128 total species collected, 49.6% (64 species) were considered rare, while 12 of the 30 genera were made-up of a majority of rare species. The 64 rare species composed nearly 50% of the entire year's species richness, but only 4.8% of the total abundance. Rare bees made up only 88 of the 1817 individual bees sampled. The family Andrenidae had the most rare species (22; 34.4% of all the rare species).

Table 2. Bee species occurring at 3 of the 4 North Georgia Apple orchards sampled during the 2010 season, excluding Mercier Orchards. Mercier Orchards, the largest orchard in Georgia, had significantly lower native bee species richness and abundance than all other orchards sampled.

Family/genus	Species	Hillside	Mt.View	Tiger	Total
ANDRENIDAE					
Andrena	*barbara*	8	4	1	13
Andrena	*crataegi*	76	414	71	561
Andrena	*fenningeri*	4	2	8	14
Andrena	*imitatrix*	1	7	3	11
Andrena	*miserabilis*	1	1	1	3
Andrena	*perplexa*	14	27	6	47
Andrena	*rugosa*	1	1	1	3
Andrena	*sayi*	1	1	1	3
Andrena	*violae*	5	8	4	17
Calliopsis	*andreniformes*	2	3	3	8
APIDAE					
Apis	*mellifera*	55	25	15	95
Bombus	*griseocollis*	1	1	2	4
Bombus	*impatiens*	3	4	9	16
Ceratina	*calcarata/dupla*	3	2	7	12
Xylocopa	*virginica*	17	16	27	60
HALICTIDAE					
Agapostemon	*sericeus*	1	5	2	8
Agapostemon	*virescens*	7	18	4	29
Augochlora	*pura*	1	11	3	15
Augochlorella	*aurata*	3	52	6	61
Halictus	*confusus*	4	4	3	11
Halictus	*ligatus/poeyi*	8	3	3	14
Lasioglossum	*callidum*	2	4	18	24
Lasioglossum	*imitatum*	28	182	12	222
Lasioglossum	*pilosum*	10	16	67	93
Lasioglossum	*puteulanum*	7	2	6	15
Lasioglossum	*tegulare*	4	1	5	10
MEGACHILIDAE					
Megachile	*mendica*	2	3	1	6
Total	Abundance	269	817	289	1375

Temporal native bee richness and abundance

We examined native bee species richness and abundance variation throughout the year. In North Georgia, the vast majority of bee species are not active in the environment from late October to late February due to the cold weather. The first bees begin to emerge in late February to early March. Apples are one of the earliest blooming commercial crops in Georgia and generally bloom around late March to early April. Thus, early emerging native bees may play a large role in Apple pollination. We divided collections from March to October into 4 parts: (1) pre-bloom, (2) Apple bloom, (3) summer (floral dearth–a period with little to no nectar producing flowers), and (4) late summer/early fall (the period associated with late-season flowers). Figure 1 diagrams species presence and absence from March to October.

*Pre-bloom***.** The pre-bloom period included all collections from the initiation of sampling to the onset of bloom, roughly March through the first week of April. In this period, 116 bees were collected, which represented 34 species. Pre-Bloom collections had the lowest abundance figures of the entire season.

Apple bloom. During the 2010 apple bloom (April 10–May 9), 1062 bees from 90 species (23 genera) were collected. The sample day of April 11 recorded the most one-day bee totals of the year, with 390 specimens. The next 2 highest collections of the 2010 sample season were also within the bloom period (April 16 with 325 bees and April 30 with 316 bees).

The most-abundant bee species, in order of abundance, were; *Andrena crataegi* (519; 48.9% of the bloom's abundance), *Lasioglossum imitatum* (62; 5.8%), *Andrena* (*Melandrena*) spp. (52; 4.9%), *Andrena perplexa* (38; 3.5%), and *Xylocopa virginica* (35; 3.2%).

Summer (floral dearth). During the post-bloom period (May 13 to July 17), 329 bees were collected (18.1% of the 2010 collection), which represented 61 species in 19 genera. Between May 9th and June 19th, an average of 58 bees were collected each sample day.

Late summer/early fall. During this period, bee abundance spikes due to the blooming of fall plants, particularly plants in the *Asteraceae* family. DuringAugust 19–October 10 2010, 310 bees were collected, or 17.1% of that year's collection. 35 species were present in the collection, predominantly from the families Apidae (14 species) and Halictidae (21 species). The Halictids, especially bees in the Genus *Lasioglossum* (260), accounted for the majority of the second flight's bee abundance.

Discussion

Native bee species richness and abundance in Georgia Apple orchards

It is important to study bee species richness, abundance, and temporal distribution in order to have a better understanding of native-bee life history as well as to determine the viability of using native bees in commercial agriculture. In our research, we have documented the native bee species diversity and abundance throughout the 2010 season in North Georgia Apple orchards. A total of 1817 bees were identified to species. These bees comprised 128 species in 30 genera in 5 families. Of the 128 bee species collected during 2010, 15 bee species were found at all 4 orchards, and 27 species were found at all the orchards except Mercier Orchards (Tables 1, 2). Several of the species were quite common at all 4 orchards. These common native bee species included: *Andrena crataegi, A. perplexa, Lasioglossum imitatum, L. pilosum,* and *Xylocopa virginica.* These results show that Georgia Apple orchards do exhibit a high level of native bee diversity and possess a large number of native bees that have the potential to serve as commercial apple pollinators.

Best sampling method

Pan traps and active sweep-netting were the most efficient methods to sample the bees. They collected 1360 bees or 76% of the bees collected and 110 of the 128 species or 86% of the species present. Vane traps were the least efficient method, collecting only 172 (9.5%) bees and 54 species. However, vane traps were better for collecting larger bees (e.g., bumble bees), which may be large enough to escape pan traps. The malaise traps collected the next fewest bees (285 bees or 15.7%); however, they did collect 11 unique species. In total, a large proportion of the species (48.4%) were collected by only one type of sampling method. These results indicate that a combination of collection methods and traps are needed to accurately assess the diversity of native bees in agricultural or natural habitats.

Potential commercial pollinator for the Southeast

We propose that *Andrena crataegi* is the best possible candidate for being a successful commercial native pollinator for North Georgia Apple production. This bee is likely an ideal pollinator for all rosid crops (cherries, peaches, pears, etc.) grown in the region. The species' sheer abundance during the bloom, generalist nature in foraging preference, conducive morphology and behavior for pollen deposition, and gregarious nesting behavior all indicate that *A. crataegi* has the best opportunity for use in North Georgia agriculture as a supplement or replacement to the Honey Bee.

Future directions

We plan to continue our research and analysis into the native Apple-pollinator guild of North Georgia during subsequent seasons. Some of our objectives include: continued monitoring and characterization of the native-bee community's abundance and diversity, quantification of the pollination efficacy of *Andrena crataegi* (and the other abundant native Apple pollinators), and testing specific habitat enrichments and other artificial manipulations to the agro-environment in order to maximize target-species abundances during the Apple bloom period.

Acknowledgments

The authors would like to thank the Apple farmers (Joe Dickey, Tim Mercier, Robert Mitchum Sr., and Robert Massee) who participated in the study. We are grateful to Sam Droege (US Native Bee Lab, US Geological Survey, Patuxent Research Center) for his aid in the identification of rare and difficult to identify bee species. Catherine Schlueter, Mehul Desai, and Peter Schlueter participated in the collection and sorting of bees. Sarah Schlueter helped prepare the manuscript and assisted with various aspects of the project. Richard Brown gave his significant feedback, which improved the usefulness of the manuscript. Funding for this study was provided by a USDA-NIFA Sustainable Agriculture Research and Education (SARE) grant OS-11-061.

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Appendix 1. Apoidea species richness and abundance from collections in four North Georgia apple orchards during the growing season, March-October 2010. Number and species is recorded for each orchard and for the type of collection trap or method.

Family/genus	Scientific name	Hillside	Mercier	Mtn. View	Tiger	Total	% total abundance	Pan trap	Vane trap	Malaise trap	Sweep netting
ANDRENIDAE	3 GENERA										
	47 SPECIES	178	22	510	134	844	46.45%				
Andrena	45 Species					830	45.68%				
	Andrena atlantica Mitchell	–	–	2	–	2	0.11%	2	0	0	0
	Andrena barbara Bouseman and LaBerge	8	–	4	1	13	0.72%	3	1	3	6
	Andrena barbilabris (Kirby)	–	–	3	–	3	0.17%	1	0	1	1
	Andrena bisalicis Viereck	1	–	–	3	4	0.22%	4	0	0	0
	Andrena bradleyi Viereck	4	–	–	–	4	0.22%	0	0	0	4
	Andrena carlini Cockerell	24	5	–	21	50	2.75%	14	5	1	30
	Andrena carolina Viereck	–	–	1	–	1	0.06%	0	0	1	0
	Andrena commoda Smith	1	–	–	1	2	0.11%	0	0	1	1
	Andrena confederata Viereck	1	–	–	1	2	0.11%	1	0	1	0
	Andrena crataegi Robertson	76	3	413	71	563	30.99%	68	44	76	375
	Andrena cressonii cressonii Robertson	1	–	–	–	1	0.06%	1	0	0	0
	Andrena dimorpha Mitchell	–	–	4	–	4	0.22%	0	1	0	3
	Andrena dunningi Cockerell	2	1	2	–	5	0.28%	2	0	0	3
	Andrena erythronii Robertson	1	–	–	–	1	0.06%	1	0	0	0
	Andrena fenningeri Viereck	4	1	2	8	15	0.83%	10	0	0	5
	Andrena forbseii Robertson	2	–	–	–	2	0.11%	0	0	1	1
	Andrena hilaris Smith	1	–	–	1	2	0.11%	1	0	0	1
	Andrena ilicis Mitchell	–	–	3	1	4	0.22%	3	0	0	1
	Andrena imitatrix Cresson	1	2	7	3	13	0.72%	2	1	0	10
	Andrena integra Smith	–	–	–	1	1	0.06%	1	0	0	0
	Andrena krigiana Robertson	2	–	–	–	2	0.11%	1	0	0	1
	Andrena macoupinensis Robertson	1	–	1	–	2	0.11%	0	0	2	0
	Andrena macra Mitchell	–	1	–	–	1	0.06%	1	0	0	0
	Andrena melanochroa Cockerell	–	–	1	–	1	0.06%	0	1	0	0
	Andrena miserabilis Cresson	1	–	1	1	3	0.17%	1	1	0	1
	Andrena morrisonella Viereck	1	–	11	–	12	0.66%	4	1	4	3
	Andrena nasonii Robertson	1	1	3	–	5	0.28%	2	0	1	2

Family/genus	Scientific name	Hillside	Mercier	Mtn. View	Tiger	Total	% total abundance	Pan trap	Vane trap	Malaise trap	Sweep netting
	Andrena neonana Viereck	1	–	3	–	4	0.22%	1	0	1	2
	Andrena nigrae Robertson	4	–	–	–	4	0.22%	1	0	0	3
	Andrena nivalis Smith	1	–	–	2	3	0.17%	1	0	1	1
	Andrena nuda Robertson	1	–	–	–	1	0.06%	0	0	0	1
	Andrena obscuripennis Smith	1	–	–	–	1	0.06%	0	0	1	0
	Andrena perplexa Smith	14	–	27	6	47	2.59%	6	5	14	22
	Andrena personata Robertson	–	–	1	–	1	0.06%	1	0	0	0
	Andrena placata Mitchell	–	–	1	–	1	0.06%	0	0	0	1
	Andrena pruni Robertson	7	–	–	3	10	0.55%	4	0	0	6
	Andrena rubi Mitchell	1	–	–	–	1	0.06%	0	0	1	0
	Andrena rugosa Robertson	1	–	1	1	3	0.17%	0	0	0	3
	Andrena salictaria Robertson	–	–	–	1	1	0.06%	0	0	0	1
	Andrena sayi Robertson	1	–	1	1	3	0.17%	0	0	0	3
	Andrena tridens Robertson	–	–	1	–	1	0.06%	0	0	0	1
	Andrena violae Robertson	5	7	8	4	24	1.32%	5	8	3	8
	Andrena wheeleri Graenicher	1	–	–	–	1	0.06%	0	0	0	1
	Andrena ziziae Robertson	–	–	1	–	1	0.06%	0	0	1	0
	Andrena ziziaeformis Cockerell	–	–	5	–	5	0.28%	0	0	2	3
Calliopsis	1 Species					9	0.50%				
	Calliopsis andreniformes Smith	2	1	3	3	9	0.50%	6	0	3	0
Panurginus	1 Species					5	0.28%				
	Panurginus atramontensis Crawford	5	–	–	–	5	0.28%	1	0	4	0
APIDAE	12 GENERA										
	27 SPECIES	99	47	71	94	311	17.12%				
Anthophora	1 Species					1	0.06%				
	Anthophora terminalis Cresson	1	–	–	–	1	0.06%	1	0	0	0
Apis	1 Species					128	7.04%				
	Apis mellifera L.	55	33	25	15	128	7.04%	35	8	18	67
Bombus	4 Species					32	1.76%				
	Bombus bimaculatus Cresson	–	–	–	1	1	0.06%	0	1	0	0
	Bombus griseocollis (DeGeer)	4	–	3	2	9	0.50%	0	3	3	3
	Bombus impatiens Cresson	3	4	4	9	20	1.10%	5	0	1	14

Family/genus	Scientific name	Hillside	Mercier	Mtn. View	Tiger	Total	% total abundance	Pan trap	Vane trap	Malaise trap	Sweep netting
	Bombus pensylvanicus (DeGeer)	–	–	2	–	2	0.11%	0	0	0	2
Ceratina	2 Species					19	1.76%				
	Ceratina calcarata/dupla Robertson/Say	3	2	2	7	14	0.77%	5	2	5	2
	Ceratina strenua Smith	2	–	3	–	5	0.28%	2	0	2	1
Eucera	2 Species					32	1.76%				
	Eucera hamata (Bradley)	2	3	–	22	27	1.49%	4	2	15	6
	Eucera rosae (Robertson)	1	–	2	–	3	0.17%	1	1	0	1
Habropoda	1 Species					6	0.33%				
	Habropoda laboriosa (Fabricius)	1	2	–	3	6	0.33%	1	1	1	3
Melissodes	5 Species					11	0.61%				
	Melissodes bimaculata (Lepeletier)	1	–	1	2	4	0.22%	4	0	0	0
	Melissodes desponsa Smith	–	–	1	1	2	0.11%	2	0	0	0
	Melissodes druriella (Kirby)	–	–	–	1	1	0.06%	0	0	1	0
	Melissodes tepaneca Cresson	1	–	–	–	1	0.06%	0	0	1	0
	Melissodes trinodis Robertson	–	–	2	–	2	0.11%	2	0	0	0
Melitoma	1 Species					5	0.28%				
	Melitoma taurea (Say)	2	–	–	3	5	0.28%	1	0	0	4
Nomada	7 Species					16	0.88%				
	Nomada articulata Smith	3	–	–	–	3	0.17%	0	3	0	0
	Nomada bethueni Cockerell	–	–	2	–	2	0.11%	0	0	1	1
	Nomada Bi-Dentate GROUP	–	–	2	–	2	0.11%	0	0	0	2
	Nomada cressonii Robertson	3	–	1	–	4	0.22%	0	1	0	3
	Nomada imbricata Smith	–	2	1	–	3	0.17%	2	0	1	0
	Nomada luteola Olivier	–	–	1	–	1	0.06%	0	0	0	1
	Nomada parva Robertson	–	–	1	–	1	0.06%	0	0	0	1
Peponapis	1 Species					2	0.11%				
	Peponapis pruinosa (Say)	–	–	1	1	2	0.11%	2	0	0	0
Ptilothrix	1 Species					1	0.06%				
	Ptilothrix bombiformis (Cresson)	–	–	1	–	1	0.06%	1	0	0	0
Xylocopa	1 Species					61	3.36%				
	Xylocopa virginica (Linnaeus)	17	1	16	27	61	3.36%	8	9	6	38

Family/genus	Scientific name	Hillside	Mercier	Mtn. View	Tiger	Total	% total abundance	Pan trap	Vane trap	Malaise trap	Sweep netting
COLLETIDAE	2 GENERA										
	4 SPECIES	3	0	4	1	8	0.44%				
Colletes	2 Species					4	0.22%				
	Colletes productus Robertson	1	–	–	–	1	0.06%	0	0	0	1
	Colletes thoracicus Smith	1	–	1	1	3	0.17%	2	1	0	0
Hylaeus	2 Species					4	0.22%				
	Hylaeus confluens (Smith)	–	–	2	–	2	0.11%	0	0	0	2
	Hylaeus mesillae (Cockerell)	1	–	1	–	2	0.11%	1	0	0	1
HALICTIDAE	7 GENERA										
	33 SPECIES	91	19	352	160	622	34.23%				
Agapostemon	3 Species					44	2.42%				
	Agapostemon sericeus (Forster)	1	1	5	2	9	0.50%	2	2	1	4
	Agapostemon splendens (Lepeletier)	–	–	–	1	1	0.06%	0	0	0	1
	Agapostemon virescens (Fabricius)	7	3	18	6	34	1.87%	14	1	7	12
Augochlora	1 Species					16	0.88%				
	Augochlora pura (Say)	2	–	11	3	16	0.88%	8	3	2	3
Augochlorella	1 Species					63	3.47%				
	Augochlorella aurata (Smith)	3	1	52	7	63	3.47%	44	9	3	7
Augochloropsis	1 Species					2	0.11%				
	Augochloropsis metallica (Fabricius)	–	–	1	1	2	0.11%	2	0	0	0
Halictus	3 Species					29	1.60%				
	Halictus confusus Smith	5	–	4	3	12	0.66%	2	1	3	6
	Halictus ligatus/poeyi Say/Lepeletier	8	1	3	3	15	0.83%	7	0	7	1
	Halictus rubicundus (Christ)	1	–	1	–	2	0.11%	1	1	0	0
Lasioglossum	22 Species					464	25.54%				
	Lasioglossum apocyni (Mitchell)	–	–	1	2	3	0.17%	1	0	2	0
	Lasioglossum asteris Mitchell	–	–	1	–	1	0.06%	1	0	0	0
	Lasioglossum callidum (Sandhouse)	2	1	4	18	25	1.38%	15	4	4	2
	Lasioglossum coreopsis (Robertson)	–	1	1	–	2	0.11%	1	1	0	0
	Lasioglossum cressonii (Robertson)	–	–	1	1	2	0.11%	2	0	0	0
	Lasioglossum foxii (Robertson)	–	–	22	4	26	1.43%	21	1	4	0
	Lasioglossum fuscipenne (Smith)	–	–	1	1	2	0.11%	2	0	0	0

Family/genus	Scientific name	Hillside	Mercier	Mtn. View	Tiger	Total	% total abundance	Pan trap	Vane trap	Malaise trap	Sweep netting
	Lasioglossum hitchensi Gibbs	–	–	–	4	4	0.22%	2	2	0	0
	Lasioglossum illinoense (Robertson)	–	–	1	3	4	0.22%	3	0	`	0
	Lasioglossum imitatum (Smith)	28	5	182	12	227	12.49%	124	15	42	46
	Lasioglossum leucozonium (Schrank)	1	–	–	–	1	0.06%	0	1	0	0
	Lasioglossum obscurum (Robertson)	–	–	10	–	10	0.55%	3	0	7	0
	Lasioglossum pilosum (Smith)	10	1	16	67	94	5.17%	53	20	9	12
	Lasioglossum puteulanum Gibbs	7	–	2	6	15	0.83%	13	0	1	1
	Lasioglossum sopinci (Crawford)	1	–	–	–	1	0.06%	0	0	0	1
	Lasioglossum tegulare (Robertson)	4	–	1	5	10	0.55%	9	1	0	0
	Lasioglossum timothyi Gibbs	–	–	–	2	2	0.11%	1	1	0	0
	Lasioglossum trigeminum Gibbs	–	1	1	4	6	0.33%	3	2	0	1
	Lasioglossum versans (Lovell)	1	–	–	–	1	0.06%	0	1	0	0
	Lasioglossum versatum (Robertson)	2	1	3	2	8	0.44%	5	0	1	2
	Lasioglossum viridatum GROUP	6	2	9	–	17	0.94%	4	2	5	6
	Lasioglossum zephyrum (Smith)	1	1	1	–	3	0.17%	3	0	0	0
Sphecodes	2 Species					4	0.22%				
	Sphecodes prosphorus Lovell & Cockerell	–	–	–	1	1	0.06%	0	1	0	0
	Sphecodes ranunculi Robertson	1	–	–	2	3	0.17%	1	0	0	2
MEGACHILIDAE	6 GENERA										
	17 SPECIES	15	2	7	8	32	1.76%				
Anthidiellum	1 Species					1	0.06%				
	Anthidiellum notatum (Robertson)	–	–	–	1	1	0.06%	1	0	0	0
Coelioxys	1 Species					1	0.06%				
	Coelioxys dolichos Fox	–	–	–	1	1	0.06%	1	0	0	0
Hoplitis	2 Species					3	0.17%				
	Hoplitis pilosifrons (Cresson)	1	–	–	–	1	0.06%	0	0	1	0
	Hoplitis producta (Cresson)	–	1	1	–	2	0.11%	0	1	1	0
Megachile	7 Species					17	0.94%				
	Megachile albitarsis Cresson	2	–	–	–	2	0.11%	2	0	0	0
	Megachile concinna Smith	1	–	–	–	1	0.06%	0	0	1	0
	Megachile integrella Mitchell	1	–	–	–	1	0.06%	0	0	1	0
	Megachile mendica Cresson	3	–	3	1	7	0.39%	1	1	3	2

Family/genus	Scientific name	Hillside	Mercier	Mtn. View	Tiger	Total	% total abundance	Pan trap	Vane trap	Malaise trap	Sweep netting
	Megachile mucida Cresson	1	–	–	–	1	0.06%	1	0	0	0
	Megachile rotundata (Fabricius)	2	–	–	–	2	0.11%	0	0	2	0
	Megachile xylocopoides Smith	–	–	–	3	3	0.17%	3	0	0	0
Osmia	5 Species					9	0.50%				
	Osmia georgica Cresson	1	–	1	–	2	0.11%	1	0	0	1
	Osmia lignaria Say	1	–	–	1	2	0.11%	0	0	0	2
	Osmia pumila Cresson	1	1	1	–	3	0.17%	0	1	0	2
	Osmia sandhouseae Mitchell	1	–	–	–	1	0.06%	0	0	0	1
	Osmia subfasciata Cresson	–	–	1	–	1	0.06%	0	0	0	1
Stelis	1 Species					1	0.06%				
	Stelis louisae Cockerell	–	–	–	1	1	0.06%	1	0	0	0
Total	Abundance	386	90	944	397	1817		587	172	285	773
	Species richness	81	30	78	64	128		43	43	54	72