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A Checklist of the Bees (Hymenoptera: Apoidea) of St. Louis, Missouri, USA

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ABSTRACT: Concern over the declines of pollinator populations during the last decade has resulted in calls from governments and international agencies to better monitor these organisms. Recent studies of bee diversity in urban environments suggest that cities may contain significant amounts of bee species, even greater than surrounding agricultural areas, and in some occasions comparable to natural habitats. We conducted a three-year survey of bees in the city of St. Louis, MO. Like many other post-industrial cities in the United States, St. Louis is considered a shrinking city, with many vacant lots and unoccupied structures, mostly in the urban core. We sampled a broad range of habitats throughout the growing seasons of 2013 to 2016, e.g., vacant lots, city parks, community gardens, and urban farms, using aerial netting. This resulted in over 7,700 specimens. Data from other surveys, e.g., BioBlitz, and personal collections was also utilized in developing the species list. These data were supplemented with inspections of entomological collections from institutions in the state and the scientific literature. We identified a total of 198 species of bees from five different families that occur in the city. Only nine of the bee species present in the city are non-natives. The city of St. Louis currently hosts nearly 45% of the bee diversity of the state, likely making it one of most species-rich cities relative to its state's total bee fauna in the country. This represents a great natural resource that must be better understood, and has potential conservation implications.

KEY WORDS: Anthophila, urban biodiversity, urban pollinators, shrinking city, novel ecosystem

Bees are arguably the most important pollinators on a global scale (Buchmann and Nabhan, 1996). Yet, many species are in trouble (Shepherd *et al.*, 2003; Winfree, 2010). Declines of honeybees and North American native bees, such as bumblebees, have been reported over the past decade (Grixti *et al.*, 2009; Williams and Osborne, 2009; Winfree *et al.*, 2009). The status of many native bees is not well understood, and according to some has already reached a crisis stage (Dixon, 2009). The dire lack of data is perhaps best described by the National Academy of Sciences (2007) in a recent report on the status of pollinators: ". . .the paucity of long-term data and the incomplete knowledge of even basic taxonomy and ecology make the definitive assessment of status exceedingly difficult." It is estimated that there are over 20,000 species worldwide (Michner, 2000), and around 4000 in the continental United States (Wilson and Carrill, 2015). For the state of Missouri, it is estimated that there are some 452 species of bees (M. Arduser, unpublished data). Yet, little is known about the distribution of bees for urban environments in general, and for the city of St. Louis in particular.

As of the year 2000, approximately half of the world's population lives in urban areas (Millennium Ecosystem Assessment, 2005). The same report proposed that by the middle of the century, two out of every three human beings will be living in an urban environment. At the same time, the pressure on agricultural systems to produce food for all those people will be greater than ever. Thus, understanding the mechanisms that maintain and

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mediate pollinator diversity and abundance in urban environments is critical (Garibaldi *et al.*, 2014).

The current approach to native bee conservation is habitat enhancement (Shepherd, 2002; Shepherd *et al.,* 2003; Shepherd *et al.,* 2008). Common recommendations include providing nesting and foraging resources in developed landscapes in hopes that pockets of suitable habitat will sustain diverse bee communities. Human population decline in the urban core of St. Louis city, further exacerbated by widespread foreclosures during the economic recession of 2008–2010, have created novel ecosystems (Morse *et al.*, 2014) that hint at potential sites for general conservation (Frazier and Bagchi-Sen, 2015), and insect pollinators specifically (Gardiner *et al.*, 2013; Burr *et al.*, 2016). Many of these newly open spaces could be considered enhanced habitat from the perspective of native bees (Baldock *et al.,* 2015; Threlfall *et al.,* 2015; Hall *et al.*, 2016). Abandoned buildings, or those in disrepair, may provide cavities for females to nest. Brownfields and open lots provide undisturbed soils for ground-dwelling species, and weedy vegetation that can be quite attractive, as typical urban-exploiting plant species such as clover and various asters are highly attractive to bees. Utilization of a small proportion of these lots by the community to convert them into parks or community gardens further enhances sites (Frazier and Bachi-Sen, 2015) and potentially provides more resources for native bee conservation (Burr *et al.*, 2016; Hall *et al.*, 2016).

Indeed, recent work has proposed that cities may represent a refuge of sorts for many wild bees (Hall *et al*., 2016). For example, the bulk of the bee diversity in England resides in urban environments instead of more natural or agrarian habitats (Baldock *et al.,* 2015). Less striking, yet still surprisingly high levels of bee diversity have been observed in Berlin, Germany (Saure *et al.,* 1998), Melbourne, Australia (Threlfall *et al.,* 2015), Guanacaste Province, Costa Rica (Frankie *et al.,* 2013), Vancouver, Canada (Tommasi *et al.,* 2004), Chicago, IL (Tonietto *et al.,* 2011; Lowenstein *et al.*, 2014), and New York City, NY (Matteson *et al.,* 2008; Matteson and Langellotto, 2009).

The objective of our study was to assemble a comprehensive checklist of bee species for St. Louis city that could serve as a comparison to other urban environments, and as a reference for further studies in the St. Louis metropolitan area. St. Louis is representative of the post-industrial, rust-belt, Midwestern city in North America (Gordon, 2008). There has been tremendous urban sprawl during the last twenty years, mostly to the west and south of the city, and significant shrinking of the urban core population (Miamaitijiang *et al.*, 2014). This shrinkage has led to significant abandonment of properties in the city, resulting in many vacant lots and decaying infrastructure, mostly between Interstate 44 to the south and Interstate 270 to the north (Figure 1) (Miamaitijiang *et al.,* 2014; Ganning and Tighe, 2015).

Materials and Methods

Study Area

The city of St. Louis, MO, rests on the western banks of the Mississippi river near the center of the river valley (Fig. 1). The city has an estimated population of 320,000 people in an area of 170 km^2 (Ganning and Tighe, 2015). The climate of the city is considered transitional between humid continental (Köppen climate classification *Dfa*) and humid subtropical (*Cfa*). There is no significant topographical relief in the area, with the major bodies of water being the Missouri and Mississippi rivers (Fig. 1). This lack of major geographical features results in the city experiencing very hot and

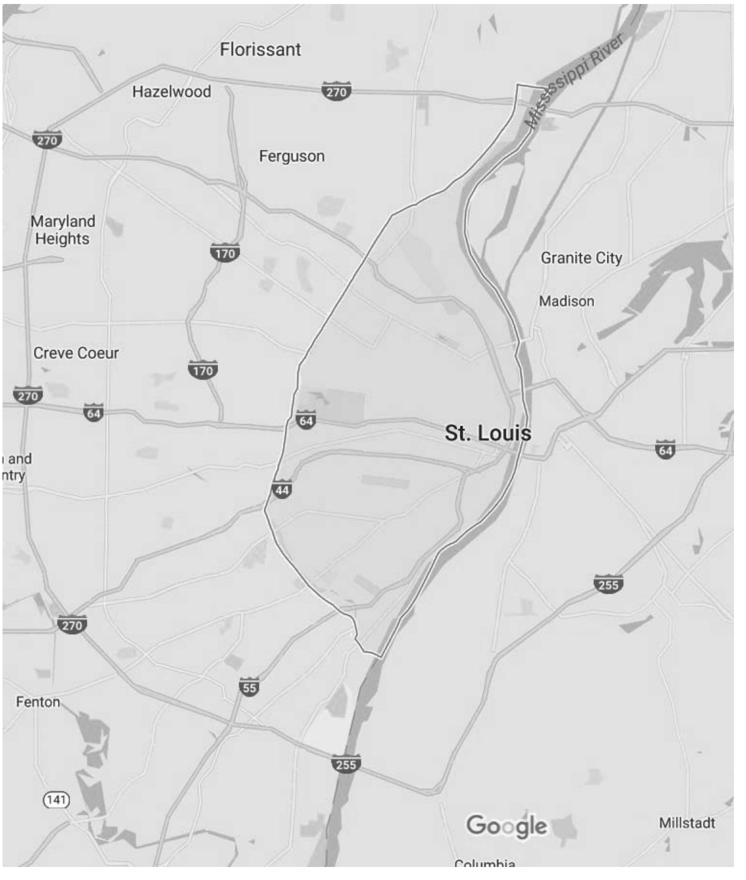

Fig. 1. Map of the St. Louis, MO, metropolitan area. The demarcations of the political boundaries of the city are highlighted. For the purpose of this study we defined "city" as the area within the Interstate Highways 255–270 to the north, west and south, and the Mississippi River to the east. Other shaded areas represent city or county parks.

humid summers (average summer temperature 31.2°C, record high 46.1°C) and very cold winters (average winter temperature −0.1°C, record −22°C). The average seasonal snowfall is 45 cm.

The vegetation of the city of St. Louis is considered to be transitional between oak-hickory dominated forests and tall grass prairie (Nigh and Schroeder, 2002). Typical of urban environments, there are many invasive and weedy plant species that tend to dominate abandoned and vacant lots, as well as riparian habitats and parks (Mühlenbach, 1979). Like many other cities (Colasanti *et al.*, 2013), there is also a tremendous resurgence and interest in agriculture across the city. This has resulted in the establishment of many community gardens and urban farms over the last decade.

For the purpose of this study, we restricted the definition of the city of St. Louis to the actual city and the surrounding suburbs contained within the Interstate Highway 270 loop to the north and to the west; Interstate Highway 255 to the south; and the Mississippi River to the east (Fig. 1). This area is almost continuously urbanized from downtown to the Interstate Highway 255/270 loop.

Specimen Sources

The bulk of the specimens (>7700) were collected between May 2013 and October 2016 as part of a wildlife conservation survey for the Missouri Department of Conservation. Most of those collections were done in urban gardens, urban farms, native vegetation sites, and restoration prairies. Other habitats sampled less often were abandoned and vacant lots, private gardens, and city parks. Sampling was done via aerial netting. All specimens from the survey are in the insect collection at Saint Louis University (SLU). Two other surveys provided significant numbers of specimens. First is the biennial BioBlitz survey of Forest Park, which started in 2004. These specimens reside in the personal collection of M. Arduser. This is the largest public park in St. Louis with an area of 523.25 ha, and it contains two restoration prairie sites, a savannah-type area, and a continuously forested area. The second survey was that of pollinators of the Litzsinger Road Ecology Center, conducted by R. Clinebell and M. W. Slagle in the late 1990's. This is an educational center managed by the Missouri Botanical Garden. It is located in the suburbs just west of the city, with an area of 13.75 ha, and contains a range of natural habitats. Specimens of this survey are deposited in the collection of the Missouri Botanical Garden (MBG) and the Litzsinger Road Ecology Center (Litzsinger). Other sources of material were specimens from the collections at The Enns Entomology Museum, University of Missouri, Columbia (UMC); The University of Missouri, St. Louis (UMSL); and the Saint Louis Zoo (SLZ). Finally, an amateur collector, Mr. George Diehl, also contributed specimens. All specimens were identified to species or morphospecies level. We followed the taxonomical convention of Michener (2000) as per modifications by Ascher and Pickering (2016). Noticeable in the UMC collection were a number of specimens collected by the US Department of Agriculture in the late 1930's as part of a survey of the invasive Japanese beetle, *Popillia japonica*, in St. Louis. According to a report by M. E. Brown in 1996, most of the trapping in the 1930's St. Louis occurred between what is now the Gateway Arch grounds to the east, and Tower Grove Park to the west. This park is adjacent to the grounds of the Missouri Botanical Garden.

A word of caution concerning methods is relevant here. Specimens for this study were collected using a broad range of methods at different times, e.g., aerial netting in the 2010's and flight intercept trap in the 1930's. For many individuals we don't have any idea how they were collected or the specific locality within the city. Specimens were also collected from the early 20th century until 2016. That's almost 100 years difference. Thus, determining various diversity parameters is not appropriate in this case.

Results

A total of five families, 47 genera, and 198 species of bee species were identified as occurring in the St. Louis metro area (Table 1). The bulk of the species richness found in the city are native bees (189/198). The most species rich group was the family Apidae with 20 genera and 61 species. The family of the leaf-cuttter bees, Megachilidae, was the next most species rich with 12 genera and 45 species. The sweat bees,Family Halictidae, contained 10 genera and 44 species, whereas the mining bee family, Andrenidae, was represented by five genera and 38 species. The polyester bees, Family Colletidae, were the least diverse with two genera and 10 species. The only family reported for the state that was not observed in the city was Melittidae. Fourteen species were identified from collection specimens and have not been observed in recent surveys (Table 1). *Andrena geranii* was reported in the literature by Rau (1934), yet, we have not identified a voucher specimen for this species.

Bumble Bees

A total of nine species of the genus *Bombus* were recorded in the city (Table 1). Seven of the nine currently occur in the city and have been collected repeatedly in the last four years. Alternatively, one species, the variable cuckoo bumble bee, *B. variabilis*, is represented by a single individual collected in 1938 in the USDA Japanese beetle survey. The host species of the variable cuckoo bumble bee, the American bumble bee, *B. pensylvanicus* (Williams *et al.*, 2014), is consistently found in three locations in the city.

The rusty patched bumble bee, *B. affinis*, was collected by R. Clinebell in the Litzsinger Road Ecology Center. This collection consisted of two males and five workers in late summer of 1998. This species has not been observed in the St. Louis area ever since. *Bombus affinis* was listed as endangered by the US Fish & Wildlife Service on March 21, 2017.

Another species of high conservation concern is the southern plains bumble bee, *B. fraternus*. This species has exhibited significant declines in abundance and range over the last decade (Colla *et al.,* 2012; Hatfield *et al.,* 2014), and is listed by the IUCN as endangered (Hatfield *et al.,* 2014). We have identified two locations within the city that have populations of this species, one an urban farm, the other a restoration prairie.

The eastern common bumble bee, *B. impatiens*, was the most prevalent bumble bee in all agricultural sites. It was also present in all native vegetation sites, and only absent from vacant lots. This species was active from late May all the way until the middle of October in all years that we sampled.

Non-natives Bees

A total of nine non-native bees were identified as occurring in the city (Table 1). The most common non-native across the entire city was the honeybee, *Apis mellifera*, with as much as ten times higher abundance than any other species. Even when hives were not observed in the vicinity, honeybees were prevalent. Over half of the sites surveyed had hives present, or hives were observed nearby.

The second most common non-native was the European wool carder bee, *Anthidium manicatum*. This species was found mostly in community gardens and urban farms. It was much less abundant, or even absent, from areas that contained mostly native vegetation. This species was commonly associated with lamb's ears, *Stachys byzantina*. Females of this species visit the lamb's ears leaves from which they 'card' the trichomes for nesting material (Smith, 1991).

One of the most recent additions to the bee community in St. Louis is the giant Asian resin bee, *Megachile sculpturalis*. It is believed that this species was introduced in the early 1990's into the east coast, near Baltimore (Batra, 1998). A decade later it was detected in the state of Kansas (Hinojosa-Díaz, 2008). The earliest record of this species in the city of St. Louis is also from 2008. This species is mostly found in community gardens and urban farms associated with Russian sage, *Perovskia atriplicifolia*. We never observed it in areas that contained only native vegetation. This species has also been identified pollinating kudzu, *Pueraria lobata*, in the St. Louis area (S. Callen, unpublished data).

The third most common non-native was the alfalfa leaf-cutter bee, *Megachile rotundata*. This species was also more abundant in agricultural habitats, and almost entirely absent from native vegetation sites.

Table 1. Checklist of the bee species reported for St. Louis city, MO. The list is assembled alphabetically for species within genus, and genera within families. For each species we indicate if the species is native or introduced, and list the collection(s) where the voucher specimens resides. Species in bold font have not been observed in recent times within city limits, 1990 to present.

	Taxon	Origin	Voucher
	ANDRENIDAE		
1	*Andrena accepta* Viereck	native	Arduser/SLZ
2	*Andrena barbara* Bouseman and LaBerge	native	Arduser
3	*Andrena brevipalpis* Cockerell	native	Arduser
4	*Andrena carlini* Cockerell	native	SLZ
5	*Andrena cressonii* Robertson	native	SLU/SLZ
6	*Andrena commoda*Smith	native	Arduser
7	*Andrena crataegi* Robertson	native	UMC
8	*Andrena erythrogaster* (Ashmead)	native	UMC/Arduser
9	*Andrena forbesii* Robertson	native	Arduser
10	***Andrena geranii* (Robertson)***	native	
11	*Andrena helianthi* Robertson	native	SLU
12	*Andrena hippotes* Robertson	native	Arduser
13	*Andrena ilicis* Mitchell	native	Litzinger
14	*Andrena illini* Bouseman and LaBerge	native	SLZ/UMC
15	*Andrena illinoensis* Robertson	native	Litzinger
16	*Andrena mandibularis* Robertson	native	UMC
17	*Andrena imitatrix* Cresson	native	SLU/SLZ
18	*Andrena miserabilis* Cresson	native	SLU/SLZ
19	*Andrena nasonii* Robertson	native	SLU/SLZ
20	*Andrena nuda* Robertson	native	MBG
21	*Andrena perplexa* Smith	native	SLZ
22	*Andrena personata* Robertson	native	Litzinger
23	*Andrena phaceliae* Mitchell	native	Litzinger
24	*Andrena polemonii* Robertson	native	Litzinger
25	*Andrena robertsonii* Dalla Torre	native	Litzinger
26	*Andrena rudbeckiae* Robertson	native	SLU/SLZ
27	*Andrena sayi* Robertson	native	Litzinger
28	*Andrena simplex* Smith	native	Arduser/SLZ
29	*Andrena violae* Robertson	native	SLU/SLZ
30	*Andrena wilkella* (Kirby)	introduced	SLU/SLZ
31	*Anthemurgus passiflorae* Robertson	native	SLU
32	*Calliopsis andreniformis* Smith	native	SLU
33	***Protandrena bancrofti* Dunning**	native	UMC
34	***Protandrena cockerelli* Dunning**	native	UMC
35	*Pseudopanurgus albitarsis* (Cresson)	native	Arduser
36	*Pseudopanurgus compositarum* (Robertson)	native	Arduser/SLZ
37	*Pseudopanurgus labrosus* (Robertson)	native	Arduser
38	*Pseudopanurgus rudbeckiae* (Robertson)	native	Arduser
	APIDAE		
39	*Anthophora abrupta* Say	native	SLU
40	*Anthophora ursina* Cresson	native	UMC/Arduser
41	*Anthophora terminalis* Cresson	native	SLZ/MBG
42	*Apis mellifera* Linnaeus	introduced	SLU/SLZ
43	*Bombus affinis* Cresson	native	MBG
44	*Bombus auricomus* (Robertson)	native	SLU/SLZ
45	*Bombus bimaculatus* Cresson	native	SLU/SLZ
46	*Bombus fervidus* (Fabricius)	native	SLU
47	*Bombus fraternus* (Smith)	native	SLU

Table 1. Continued.

	Taxon	Origin	Voucher
48	*Bombus griseocollis* (DeGeer)	native	SLU/SLZ
49	*Bombus impatiens* Cresson	native	SLU/SLZ
50	*Bombus pennsylvanicus* (DeGeer)	native	SLU/SLZ
51	*Bombus variabilis* (Cresson)	native	UMC/MBG
52	***Cemolobus ipomoeae* (Robertson)**	native	UMC
53	*Ceratina calcarata* Robertson	native	SLU/SLZ
54	*Ceratina dupla* Say	native	SLZ
55	*Ceratina strenua* Smith	native	SLU/SLZ
56	*Diadasia australis* (Cresson)	native	SLZ
57	*Eucera hamata* (Bradley)	native	SLU/SLZ
58	*Eucera rosae* (Robertson)	native	SLU
59	*Epeolus bifasciatus* Cresson	native	SLU
60	*Florilegus condignus* (Cresson)	native	SLZ
61	*Habropoda laboriosa* (Fabricius)	native	SLU/SLZ
62	*Holcopasites calliopsidis* (Linsley)	native	SLU
63	*Melissodes agilis* Cresson	native	SLU/SLZ
64	*Melissodes bimaculatus* Lepeletier	native	SLU/SLZ
65	*Melissodes boltoniae* Robertson	native	Arduser
66	*Melissodes communis* Cresson	native	SLU
67	*Melissodes comptoides* Robertson	native	SLU/SLZ
68	*Melissodes coreopsis* Robertson	native	Arduser
69	*Melissodes denticulatus* Smith	native	SLU/SLZ
70	*Melissodes dentiventris* Smith	native	Arduser/SLZ
71	*Melissodes desponsus* Smith	native	SLU/SLZ
72	*Melissodes druriellus* (Kirby)	native	Arduser/SLZ
73	*Melissodes trinodis* Robertson	native	SLU/SLZ
74	*Melissodes vernoniae* Robertson	native	SLU/UMC
75	*Melitoma taurea* (Say)	native	SLU/SLZ
76	*Nomada texana*	native	SLZ
77	*Nomada sp. 1*	native	SLU
78	*Nomada sp. 2*	native	SLU
79	*Nomada sp. 3*	native	SLU
80	*Nomada sp. 4*	native	SLU
81	*Nomada sp. 5*	native	SLU
82	*Nomada sp. 6*	native	SLU
83	*Nomada sp. 7*	native	SLU
84	*Nomada sp. 8*	native	SLU
85	*Nomada sp. 9*	native	SLU
86	*Peponapis pruinosa* (Say)	native	SLU/SLZ
87	*Ptilothrix bombiformis* (Cresson)	native	SLU/SLZ
88	*Triepeolus atripes* Mitchell	native	Arduser
89	*Triepeolus concavus* (Cresson)	native	SLU
90	*Triepeolus helianthi* (Robertson)	native	Litzinger
91	*Triepeolus lunatus* (Say)	native	SLU
92	*Triepeolus quadrifasciatus* (Say)	native	SLU
93	*Triepeolus remigatus* (Fabricius)	native	SLU
94	*Triepeolus simplex* Robertson	native	Litzinger
95	*Triepeolus sp.*	native	SLU
96	*Svastra obliqua* (Say)	native	SLU/SLZ
97	*Xenoglossa strenua* (Cresson)	native	SLU
98	*Xenoglossa kansensis* Cockerell	native	SLZ
99	*Xylocopa virginica* (Linnaeus)	native	SLU/SLZ

Table 1. Continued.

	Taxon	Origin	Voucher
	COLLETIDAE		
100	*Colletes compactus* Cresson	native	Arduser
101	*Colletes inaequalis* Say	native	SLU
102	***Colletes latitarsis* Robertson**	native	UMC
103	*Hylaeus affinis* (Smith)	native	Litzinger
104	*Hylaeus fedorica* (Cockerell)	native	SLU
105	*Hylaeus illinoisensis* (Robertson)	native	SLU/SLZ
106	*Hylaeus leptocephalus* (Morawitz)	introduced	SLU
107	*Hylaeus mesillae* (Cockerell)	native	SLU/SLZ
108	*Hylaeus modestus* Say	native	SLU/SLZ
109	*Hylaeus sp.*		Litzinger
	HALICTIDAE		
110	*Agapostemon virescens* (Fabricius)	native	SLU/SLZ
111	*Agapostemon sericeus* (Forster)	native	SLZ
112	*Agapostemon splendens* (Lepeletier)	native	SLU
113	*Agapostemon texanus* Cresson	native	SLU
114	*Augochlora pura* (Say)	native	SLU/SLZ
115	*Augochlorella aurata* (Smith)	native	SLU/SLZ
116	*Augochlorella persimilis* (Viereck)	native	SLU
117	*Augochloropsis fulgida* (Smith)	native	SLU/SLZ
118	***Augochloropsis metallica* (Fabricius)**	native	UMC
119	*Dieunomia heteropoda* (Say)	native	SLU
120	***Dieunomia triangulifera* (Vachal)**	native	UMC
121	***Dufourea marginata* (Cresson)**	native	UMC
122	*Halictus confusus* Smith	native	SLU/SLZ
123	*Halictus ligatus* Say	native	SLU/SLZ
124	*Halictus parallelus* Say	native	UMC/Arduser
125	*Halictus rubicundus* (Christ)	native	SLU/SLZ
126	*Lasioglossum bruneri* (Crawford)	native	SLZ
127	*Lasioglossum callidum* (Sandhouse)	native	SLZ
128	*Lasioglossum cattellae* (Ellis)	native	Arduser
129	*Lasioglossum cinctipes* (Provancher)	native	SLU
130	*Lasioglossum coeruleum* (Robertson)	native	SLU/SLZ
131	*Lasioglossum coriaceum* (Smith)	native	Arduser
132	*Lasioglossum cressonii* (Robertson)	native	SLU/SLZ
133	*Lasioglossum ephialtum* Gibbs	native	SLU
134	*Lasioglossum forbesii* (Robertson)	native	SLZ
135	*Lasioglossum foxii* (Robertson)	native	SLZ
136	*Lasioglossum hitchensi* Gibbs	native	SLU/SLZ
137	*Lasioglossum illinoense* (Robertson)	native	SLZ
138	*Lasioglossum imitatum* (Smith)	native	SLU/SLZ
139	*Lasioglossum lustrans* (Cockerell)	native	SLU
140	*Lasioglossum obscurum* (Robertson)	native	SLZ
141	*Lasioglossum oenotherae* (Stevens)	native	UMC
142	*Lasioglossum pectinatum* (Robertson)	native	SLU
143	*Lasioglossum pectorale* (Smith)	native	SLU/SLZ
144	*Lasioglossum pictum* (Crawford)	native	Litzinger
145	*Lasioglossum pilosum* (Smith)	native	SLU
146	*Lasioglossum platyparium* (Robertson)	native	Arduser
147	*Lasioglossum tegulare* (Robertson)	native	SLU/SLZ
148	*Lasioglossum truncatum* (Robertson)	native	Litzinger

Table 1. Continued.

	Taxon	Origin	Voucher
149	*Lasioglossum versatum* (Robertson)	native	Arduser
150	*Lasioglossum zephyrum (*Smith*)*	native	SLU/SLZ
151	*Nomia nortoni* Cresson	native	UMC
152	*Sphecodes heraclei* Robertson	native	Diehl
153	*Sphecodes sp.*	native	SLU
	MEGACHILIDAE		
154	*Anthidiellum notatum* (Latreille)	native	SLU
155	*Anthidium manicatum* (Linnaeus)	introduced	SLU/SLZ
156	*Anthidium oblongatum* (Illiger)	introduced	SLU/SLZ
157	*Anthidium psoraleae* Robertson	native	SLU
158	*Chelostoma philadelphi* (Robertson)	native	SLU
159	*Coelioxys germanus* Cresson	native	UMC
160	***Coelioxys hunteri* Crawford**	native	UMC
161	*Coelioxys modestus* Smith	native	MBG/UMC
162	*Coelioxys octodentatus* Say	native	SLU
163	*Coelioxys obtusiventris* Crawford	native	SLU
164	*Coelioxys sayi* Robertson	native	SLU
165	*Dianthidium curvatum* (Smith)	native	SLZ
166	*Heriades carinata* Cresson	native	SLU
167	*Heriades leavitti* Crawford	native	Arduser/SLZ
168	*Heriades variolosa* (Cresson)	native	Arduser
169	*Hoplitis pilosifrons (*Cresson*)*	native	SLU/SLZ
170	*Hoplitis producta* (Cresson)	native	SLU
171	*Megachile addenda* Cresson	native	SLU
172	*Megachile apicalis* Spinola	introduced	SLU
173	*Megachile brevis* Say	native	SLU/SLZ
174	*Megachile campanulae (*Robertson*)*	native	SLU/SLZ
175	*Megachile concinna* Smith	introduced	SLU/SLZ
176	*Megachile exilis* Cresson	native	SLU/SLZ
177	*Megachile frugalis* Cresson	native	SLU
178	*Megachile gemula* Cresson	native	Litzinger
179	*Megachile inimica* Cresson	native	SLU/SLZ
180	*Megachile latimanus* Say	native	UMC
181	*Megachile mendica* Cresson	native	SLU/SLZ
182	*Megachile montivaga* Cresson	native	SLZ
183	***Megachile parallela* Smith**	native	UMC
184	*Megachile petulans* Cresson	native	Arduser
185	*Megachile policaris* Say	native	UMC/Arduser
186	*Megachile texana* Cresson	native	SLU/SLZ
187	*Megachile rotundata* (Fabricius)	introduced	SLU/SLZ
188	*Megachile sculpturalis* Smith	introduced	SLU/SLZ
189	*Megachile xylocopoides* Smith	native	SLU/SLZ
190	*Osmia atriventris* Cresson	native	UMC
191	*Osmia bucephala* Cresson	native	Arduser
192	***Osmia cordata* Robertson**	native	UMC
193	*Osmia georgica* Cresson	native	SLU
194	*Osmia lignaria* Say	native	SLU
195	*Osmia pumila* Cresson	native	SLU/SLZ
196	*Osmia subfasciata* Cresson	native	SLU
197	*Stelis louisae* Cockerell	native	Arduser
198	*Stelis lateralis* Cresson	native	SLZ

*This species is only known from St. Louis by a report in the scientific literature (Rau, 1934), and no voucher specimen currently exists.

Cleptoparasites

We recorded a total of 32 species of cleptoparasitic bees in the city of St. Louis. That is 16% of the bee fauna, a higher percentage than what has been reported for New York City (Matteson *et al.,* 2008), Chicago, IL (Pearson, 1933; Tonietto *et al.,* 2011; Molumby and Przybylowicz, 2012), and even a restoration prairie located 135 miles north of St. Louis (Geroff *et al.*, 2014).

Of notable interest is the presence of *Ceolioxys obtusiventris*. This species is one of the most rare bees of North America, with only a handful of females (<20) ever found (Ascher and Pickering, 2016). This species was originally described based on a single specimen from Florida (Crawford, 1914), and then a second specimen reported in Indiana (Chandler, 1969). We have collected this species twice in an urban farm in the suburb of Ferguson, with both occasions taking place in the month of July 2014 and 2016.

Discussion

We identified 198 bee species in the city of St. Louis. In the state of Missouri, there are six families and 452 reported bee species (M. Arduser, in preparation). Almot 45% of the bee fauna of the state of Missouri has been recorded in the city of St. Louis (198/452). In terms of raw species richness, St. Louis bee diversity is higher than that of restored prairie systems in the Midwest United States (Geroff *et al.,* 2014), and is comparable to the natural environment that is the Indiana Dunes (Grundel *et al.,* 2011).

In general, the flora and fauna of cities tend to be dominated by generalists, with a significant amount of non-native species (McKinney, 2008). We observed a relatively low number of introduced species (Table 1), especially when compared to studies from Chicago (Tonietto *et al.,* 2011; Molumby and Przybylowicz, 2012) and New York (Matteson *et al.,* 2008). There are two general possibilities for this. First, being located in the center of the continent provides a geographic barrier to non-natives, given that most of those species arrive at ports of entry in coastal cities (Lockwood *et al.,* 2013). The second possibility is that the dominance of the native bee species can keep some of the non-native species from establishing (Lockwood *et al.,* 2013). These two hypotheses are not mutually exclusive, and could be effectively interacting in the St. Louis environment.

We did record several specialist bees across the city. The hibiscus bee, *Ptilothrix bombiformis*, was recorded from community gardens that featured rose mallow, *Hibiscus moscheutos*, or Rose of Sharon, *Hibiscus syriacus*. *Ptilothrix* was collected mostly in these plants, but in one occasion was collected from a cultivated variety of iris. We recorded three species of squash bee: *Peponapis pruinosa, Xenoglossa kansensis, and X. strenua*. We also collected several specialists on sunflowers, like *Svastra obliqua* and *Dieunomia heteropoda.* Furthermore, all cleptoparasitic bees are essentially specialists. Within the city of St. Louis, we identified 32 species of cleptoparasitic bees (Table 1). This group is proposed to be indicators of the overall stability of the bee community given that cleptoparasites are host specialists and require the presence and abundance of the host species in order to maintain a viable population (Scheffield *et al*., 2013).

There is paucity in the reporting of native bee diversity for most habitats. A survey of the bees of the Indiana Dunes, a botanical rich native habitat in northwestern Indiana, revealed a total of 175 species (Grundel *et al.,* 2011). The most species rich genus in the Indiana Dunes habitat was *Lassioglossum*, with 25% of the species. In our study, although the genus *Lassioglossum* was also the most species rich (20 spp.), yet, it contained only 12% of the species (Table 1). This is likely due to the fact that many *Lassioglossum* species are sandy soil specialists and the dunes provide an ideal habitat. The Indiana Dunes, which represents less than 0.1% of the area of the state, contain nearly half of the bee species in the state. While this is likely the result of a combination of biogeographic, edaphic and climatic forces (Grundel *et al.*, 2011), the high bee diversity in the city of St. Louis is likely the result of socioeconomic and ethnic processes.

For cities, there is an even greater lack of reported bee diversity. The state of Illinois contains some 500 species of bees (R. Tonietto, personal communication). Pearson (1933) reported 169 for the Chicago region. Yet, many of the localities that he lists are at considerable distances from what even today are urbanized areas. A more recent estimate of the bee diversity for the greater Chicago metro area, which is the third largest city in the United States and more than twice the area of St. Louis, is 93 species (Molumby and Przybylowicz, 2012). Therefore, the Chicago area contains less than one fifth of the state's bee fauna. Furthermore, the bee diversity within the city limits of is estimated to be 68 species (Minor *et al.*, 2016). The large bee diversity in the city of St. Louis is noteworthy and must be further investigated to determine the specific characteristics that maintain this large diversity.

Over the last decade there has been increased concern over the conservation status of many pollinators at the national (National Academy of Sciences, 2007; USA President's Task Force Strategy on Pollinator Health, 2015) and international levels (IPBES, 2016). Many food producing systems, and thus food security, depend on pollinator services mostly provided by bees. Furthermore, many wildlife species depend also on pollination services for their foraging and nutritional needs. A recent report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2016) estimates that as many as 40% species of pollinators worldwide are declining, threatened, or endangered. For many conservation practitioners involved in managing pollinator populations, it is crucial to understand how much diversity is present and how is distributed. Traditionally, efforts to conserve pollinator biodiveristy have been mostly focused on natural areas that could be protected or managed with relatively minimal human intervention. We need to consider that at times part of the pollinator conservation strategy might be "the city." There is no denying that urbanization has resulted in significant loss of biodiversity (McKinney 2008, Butchart *et al.*, 2010), and pollinators are not immune (Potts *et al.*, 2010, Hadley and Betts, 2012). Yet, recent studies (Baldock *et al.*, 2015; Ives *et al.*, 2015; Hall *et al.*, 2017) suggest that we need to incorporate the role that novel urban ecosystems have in our understanding for the biological conservation of pollinators.

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