

**A LIST OF BEE SPECIES (HYMENOPTERA: APOIDEA)
RECORDED FROM THREE MUNICIPALITIES IN THE NIAGARA
REGION OF ONTARIO, INCLUDING A NEW RECORD OF
LASIOGLOSSUM FURUNCULUM GIBBS (HALICTIDAE) IN
CANADA**

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Abstract

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We carried out an extensive survey of bee species in the Niagara Region of Ontario, Canada, by sampling various sites within three municipalities from 2003 to 2013. The municipalities were St. Catharines, Port Colborne, and Wainfleet. Sampling mainly consisted of pan-trapping, but also included sweeping through vegetation and targeted collection from flowers. In the longest ongoing survey of a bee community to date in Canada, we collected 51,842 bee specimens comprising nearly 150 valid species, of which 30 were not previously recorded for the region. We also present the first record of the rare sweat bee species *Lasioglossum furunculum* Gibbs (Hymenoptera: Halictidae) in Canada, which was previously known only from Massachusetts, United States of America.

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Introduction

Our first survey of a bee community in the Niagara Region of southern Ontario, Canada, was carried out in 2003 at 8 sites on the Brock University campus and the adjacent Glenridge Quarry Naturalization Site in St. Catharines in the northeastern tier of the Niagara Peninsula (43.1 °N, 79.2 °W; Richards *et al.* 2011). The St. Catharines sites included relatively undisturbed meadows and fields on the Brock University campus, as well as regeneration sites at the Glenridge Quarry Naturalization Site, a former landfill.

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Descriptions of the St. Catharines sites and the history of the area (natural and in terms of human activity) were provided in Richards *et al.* (2011). The St. Catharines sites were sampled each year from 2004 until 2013, except 2007, for a total of ten years of sampling. From 2011 to 2013, bees were also systematically sampled at two landfill regeneration sites in southern Niagara Peninsula, the Elm Street Naturalization Site in Port Colborne, Ontario (42.9 °N, 79.3 °W), and the Station Road Naturalization Site in Wainfleet, Ontario (42.9 °N, 79.4 °W). The sites in Port Colborne and Wainfleet are located on sites that from the 1950s until 2009 and 2008, respectively, functioned as municipal landfills. By 2011, these landfills had been capped with clay, covered with soil, and planted with an array of flowering plant species native to North America.

Our objective in the present study is to provide the list of bee species collected from our sites in these three municipalities of the Niagara Region. All three sampling areas are within the Carolinian Zone, which includes tallgrass prairie and woodland communities. Considering the proximity (< 30 km) of the sites and the longer sampling effort at St. Catharines, we expected that the species lists compiled for the Port Colborne and Wainfleet municipalities would be subsets of the St. Catharines list.

Methods

Bees were collected using three methods: pan-traps (2003–2006, 2008–2013), sweep-netting vegetation (2003–2005), and aerial netting from flowers (2003–2005, 2011–2013). Details on sampling methodology are provided in Richards *et al.* (2011) and Rutgers-Kelly and Richards (2013). While combining specimens from all these collecting methods maximized the number of species likely to be collected (Wilson *et al.* 2008), non-standard sampling across years and sites means that it is difficult to quantify and compare the proportional representations of bee species in the community.

All specimens were pinned and labelled, and are currently deposited in the research collection of M. H. Richards at Brock University. The majority of specimens collected in St. Catharines after 2003 were identified by T. M. Onuferko, and those collected in Port Colborne and Wainfleet from 2011–2013 were identified by R. Kutby and T. M. Onuferko. The following taxonomic keys were used to identify specimens in conjunction with online keys available on Discover Life (Ascher and Pickering 2015): Colla *et al.* (2011) for *Bombus* Latreille (Hymenoptera: Apidae); Gibbs (2010, 2011) for *Lasioglossum* Curtis (Hymenoptera: Halictidae) subgenus *Dialictus* Robertson; Gibbs *et al.* (2013) for *Lasioglossum* subgenera *Evylaeus* Robertson, *Hemihalictus* Cockerell, and *Sphecodogastra* Ashmead; Mitchell (1960, 1962) for *Halictus* Latreille (Hymenoptera: Halictidae) and *Sphecodes* Latreille (Hymenoptera: Halictidae); McGinley (1986) for *Lasioglossum* subgenera *Lasioglossum* and *Leuchalictus* Warncke; Rehan and Richards (2008) and Rehan and Sheffield (2011) for *Ceratina* Latreille (Hymenoptera: Apidae); Rightmyer (2008) for *Triepeolus* Robertson (Hymenoptera: Apidae); and Sheffield *et al.* (2011b) for *Megachile* Latreille (Hymenoptera: Megachilidae). Discover Life keys (Ascher and Pickering 2015) were used for the following genera: *Agapostemon* Guérin-Ménéville (Hymenoptera: Apidae), *Anthidium* Fabricius (Hymenoptera: Megachilidae), *Anthophora* Latreille (Hymenoptera: Apidae), *Calliopsis* Smith (Hymenoptera: Andrenidae), *Chelostoma* Latreille (Hymenoptera: Megachilidae),

Coelioxys Latreille (Hymenoptera: Megachilidae), *Heriades* Spinola (Hymenoptera: Megachilidae), *Hoplitis* Klug (Hymenoptera: Megachilidae), *Hylaeus* Fabricius (Hymenoptera: Colletidae), *Melissodes* Latreille (Hymenoptera: Apidae), *Osmia* Panzer (Hymenoptera: Megachilidae), and *Stelis* Panzer (Hymenoptera: Megachilidae). Females of the following species pairs are very difficult to differentiate, and identifications were largely based on male characters: *Ceratina dupla* Say versus *C. mikmaqi* Rehan and Sheffield, and *Hylaeus affinis* (Smith) versus *H. modestus* Say. Specimens of *Nomada* Scopoli (Hymenoptera: Apidae), a genus in need of revision, were kindly identified by Sam Droege (US Geological Survey, Patuxent Wildlife Research Center, Beltsville, Maryland). All *Andrena* Fabricius (Hymenoptera: Andrenidae) designations were made by Cory Sheffield (Royal Saskatchewan Museum, Regina, Saskatchewan), for which we are most grateful, and Jason Gibbs (Michigan State University, East Lansing, Michigan) graciously helped to identify many of the *Lasioglossum* specimens, including one new record for Canada.

Results

A total of 51,842 bee specimens were collected, comprising 149 species and 1 morphospecies of *Nomada*. Richards *et al.* (2011) had previously identified 124 species and morphospecies from the 2003 samples, including four distinct morphospecies and one unknown species of *Nomada*. In the present study, these *Nomada* have been collapsed into a single bidentate morphospecies group, as suggested by taxonomic expert Sam Droege. In the present study, 30 valid species not recorded by Richards *et al.* (2011) were identified (see Table 1 for a list of these and all other species sampled). All species belonged to the five most common bee families occurring in North America (Andrenidae, Apidae, Colletidae, Halictidae, and Megachilidae); no bees of the small and uncommon family Melittidae were sampled or observed. Of the 30 bee genera represented, only the cleptoparasitic genus *Triepeolus* was not previously recorded by Richards *et al.* (2011). Almost a third (9/30) of the new species added are cleptoparasitic or socially parasitic, one of which is described for the first time in Canada in the section that follows. The most speciose family sampled was Halictidae (54 species), and the least speciose was Colletidae (11 species). The present ranking of families by morphospecies richness (Halictidae > Apidae > Megachilidae > Andrenidae > Colletidae) generally matches that of Richards *et al.* (2011) (Halictidae > Apidae = Megachilidae > Andrenidae > Colletidae).

New record for Canada: *Lasioglossum (Dialictus) furunculum* Gibbs

Lasioglossum furunculum is a species that was recently described from Massachusetts, United States of America, from a single specimen (Gibbs 2011). It is most similar to *Lasioglossum izawsum* Gibbs (Hymenoptera: Halictidae), but differs in having no preapical tooth on the mandible (Fig. 1A) and an inner metatibial spur with four rather than three branches (Gibbs 2011). Females of another similar species, *Lasioglossum simplex* (Robertson) (Hymenoptera: Halictidae), lack a carinate pronotal ridge present in the two abovementioned species (Gibbs 2011). In all three species, the gena is subequal in width to the compound eye when viewed from the side (Fig. 1B); it is conspicuously wider in other parasitic species (Gibbs 2011).

TABLE 1: A complete checklist of bee species sampled from 2003–2013 in southern St. Catharines, in Port Colborne, and in Wainfleet, Ontario, Canada. Species collected since the initial 2003 survey (Richards *et al.* 2011) are indicated by an asterisk (*). Species for which a life history trait is suspected but not confirmed, as in *LasioGLOSSUM* spp., are indicated by a question mark (?). The presence of a species within a particular municipality is denoted with an ‘X’. Foraging habit is listed as N/A for parasitic species, which do not forage.

Family and species	Life History trait			Origin	Municipality		
	Social habit	Nesting habit	Foraging habit		St. Catharines	Port Colborne	Wainfleet
Andrenidae (20 species)							
<i>Andrena (Andrena) mandibularis</i> Robertson	Solitary	Ground	Generalist	Native	X		
<i>Andrena (Andrena) thaspis</i> Graenicher	Solitary	Ground	Generalist	Native	X		
<i>Andrena (Euandrena) nigrithirta</i> (Ashmead)	Solitary	Ground	Generalist	Native	X		
* <i>Andrena (Gonandrena) fragilis</i> Smith	Solitary	Ground	<i>Cornus</i> Linnaeus (Cornaceae)	Native	X		
* <i>Andrena (Gonandrena) integra</i> Smith	Solitary	Ground	<i>Cornus</i> Linnaeus (Cornaceae)	Native	X		
<i>Andrena (Holandrena) cressonii</i> Robertson	Solitary	Ground	Generalist	Native	X		
<i>Andrena (Larandrena) miserabilis</i> Cresson	Solitary	Ground	Generalist	Native	X		
<i>Andrena (Leucandrena) erythronii</i> Robertson	Solitary	Ground	<i>Erythronium</i> Linnaeus	Native	X		
<i>Andrena (Melandrena) carlini</i> Cockerell	Solitary	Ground	(Liliaceae) Generalist	Native	X		
<i>Andrena (Melandrena) dunningi</i> Cockerell	Solitary	Ground	Generalist	Native	X		
* <i>Andrena (Melandrena) vicina</i> Smith	Solitary	Ground	Generalist	Native	X		X
<i>Andrena (Ptilandrena) erigeniae</i> Robertson	Solitary	Ground	<i>Claytonia</i> Linnaeus (Montiaceae) Brassicaceae	Native	X		X
<i>Andrena (Scaphandrena) arabis</i> Robertson	Solitary	Ground	Generalist	Native	X		
<i>Andrena (Simandrena) nasonii</i> Robertson	Solitary	Ground	Generalist	Native	X		
<i>Andrena (Simandrena) wheeleri</i> Graenicher	Solitary	Ground	Generalist	Native	X		
<i>Andrena (Simandrena) wilkella</i> (Kirby)	Solitary	Ground	Fabaceae?	Native	X		X

TABLE 1 continued...

Family and species	Life History trait			Origin	Municipality		
	Social habit	Nesting habit	Foraging habit		St. Catharines	Port Colborne	Wainfleet
<i>Andrena (Trachandrena) forbesii</i> Robertson	Solitary	Ground	Generalist	Native	X		
<i>Andrena (Trachandrena) hippotes</i> Robertson	Solitary	Ground	Generalist	Native	X		
<i>Calliopsis (Calliopsis) andreiniformis</i> Smith	Solitary	Ground	Generalist	Native	X		X
<i>Pseudopanurgus andreinoides</i> (Smith)	Solitary	Ground	Asteraceae	Native	X		
Apidae (33 species and morphospecies)							
<i>Anthophora (Clisodon) terminalis</i> Cresson	Solitary	Stems/wood	Generalist	Native	X	X	X
* <i>Anthophora (Melea) bomboides</i> Kirby	Solitary	Ground	Generalist	Native	X		X
<i>Apis (Apis) mellifera</i> Linnaeus	Eusocial	Cavities	Generalist	Exotic	X	X	X
* <i>Bombus (Bombus) terricola</i> Kirby	Eusocial	Underground	Generalist	Native	X	X	X
<i>Bombus (Cullumanobombus) griseocollis</i> (DeGeer)	Eusocial	Ground	Generalist	Native	X	X	X
<i>Bombus (Cullumanobombus) rufocinctus</i> Cresson	Eusocial	surface or underground	Generalist	Native	X	X	X
<i>Bombus (Psithyrus) citrinus</i> (Smith)	Social parasite	Nests of <i>B. impatiens</i> and <i>B. vagans</i>	N/A	Native	X		
<i>Bombus (Pyrobombus) bimaculatus</i> Cresson	Eusocial	Underground	Generalist	Native	X	X	X
<i>Bombus (Pyrobombus) impatiens</i> Cresson	Eusocial	Underground	Generalist	Native	X	X	X
<i>Bombus (Pyrobombus) ternarius</i> Say	Eusocial	Underground	Generalist	Native	X		
<i>Bombus (Pyrobombus) vagans</i> Smith	Eusocial	Ground surface or underground	Generalist	Native	X	X	X
* <i>Bombus (Subterraneobombus) borealis</i> Kirby	Eusocial	Underground	Generalist	Native	X	X	X

TABLE 1 continued...

Family and species	Life History trait			Origin	Municipality		
	Social habit	Nesting habit	Foraging habit		St. Catharines	Port Colborne	Wainfleet
<i>Bombus (Thoracobombus) fervidus</i> (Fabricius)	Eusocial	Ground surface	Generalist	Native	X	X	X
<i>Ceratina (Zadontomerus) calcarata</i> Robertson	Solitary	Stems	Generalist	Native	X	X	X
<i>Ceratina (Zadontomerus) dupla</i> Say	Solitary	Stems	Generalist	Native	X	X	X
* <i>Ceratina (Zadontomerus) mikmaqi</i> Rehan and Sheffield	Solitary	Stems	Generalist	Native	X	X	X
<i>Ceratina (Zadontomerus) strenua</i> Smith	Solitary	Stems	Generalist	Native	X		
<i>Melissodes (Apomelissodes) apicata</i> Lovell and Cockerell	Solitary	Ground	<i>Pontederia cordata</i> Linnaeus (Pontederiaceae)	Native	X		
<i>Melissodes (Eumelissodes) drurii</i> (Kirby)	Solitary	Ground	Asteraceae	Native	X		X
<i>Melissodes (Heliomelissodes) desponsa</i> Smith	Solitary	Ground	<i>Cirsium</i> Miller (Asteraceae)	Native	X	X	X
<i>Nomada articulata</i> Smith	Cleptoparasite	Nests of <i>Agapostemon</i>	N/A	Native	X		
<i>Nomada bethunei</i> Cockerell	Cleptoparasite	Unknown	N/A	Native	X		
* <i>Nomada cressonii</i> Robertson	Cleptoparasite	Nests of <i>Andrena</i> , including <i>A. crataegi</i> (not collected)	N/A	Native	X		
<i>Nomada denticulata</i> Robertson	Cleptoparasite	Nests of <i>Andrena</i>	N/A	Native	X		
<i>Nomada illinoensis</i> /sayi Robertson	Cleptoparasite	Nests of <i>Andrena</i>	N/A	Native	X		
* <i>Nomada imbricata</i> Smith	Cleptoparasite	Nests of <i>Andrena</i>	N/A	Native	X		
* <i>Nomada luteoloides</i> Robertson	Cleptoparasite	Nests of <i>Andrena</i>	N/A	Native	X		

TABLE 1 continued...

Family and species	Life History trait			Origin	Municipality		
	Social habit	Nesting habit	Foraging habit		St. Catharines	Port Colborne	Wainfleet
* <i>Nomada maculata</i> Cresson	Cleptoparasite	Nests of <i>Andrena vicina</i>	N/A	Native	X		
<i>Nomada pygmaea</i> Cresson	Cleptoparasite	Unknown	N/A	Native	X		
<i>Nomada</i> bidentate group	Cleptoparasite	Unknown	N/A	Native	X		
* <i>Tripeolus donatus</i> (Smith)	Cleptoparasite	Nests of <i>Melissodes desponsa</i>	N/A	Native	X		
* <i>Tripeolus lunatus</i> (Say)	Cleptoparasite	Nests of <i>Melissodes</i>	N/A	Native	X		
<i>Xylocopa (Xylocopoides) virginica</i> (Linnaeus)	Social	Wood	Generalist	Native	X	X	X
Colletidae (11 species)							
<i>Colletes americanus</i> Cresson	Solitary	Ground	Asteraceae	Native	X		
<i>Colletes compactus</i> Cresson	Solitary	Ground	Asteraceae	Native	X		
<i>Colletes simulans</i> Cresson <i>armatus</i> Patton	Solitary	Ground	Asteraceae	Native	X		
<i>Hylaeus (Hylaeus) annulatus</i> (Linnaeus)	Solitary	Stems/cavities	Generalist	Native	X	X	X
<i>Hylaeus (Hylaeus) mesillae</i> (Cockerell)	Solitary	Stems/cavities	Generalist	Native	X	X	X
* <i>Hylaeus (Metziella) sparsus</i> (Cresson)	Solitary	Cavities	Apiaceae	Native	X		
<i>Hylaeus (Prosopis) affinis</i> (Smith)	Solitary	Stems/cavities	Generalist	Native	X	X	X
<i>Hylaeus (Prosopis) illinoisensis</i> (Robertson)	Solitary	Stems	Generalist	Native	X		
<i>Hylaeus (Prosopis) modestus</i> Say	Solitary	Stems/cavities	Generalist	Native	X	X	X
<i>Hylaeus (Spatulariella) hyalinatus</i> Smith	Solitary	Stems	Generalist	Exotic	X		X
* <i>Hylaeus (Spatulariella) punctatus</i> (Brullé)	Solitary	Pre-existing cavities	Generalist?	Exotic	X		X

TABLE 1 continued...

Family and species	Life History trait			Origin	Municipality		
	Social habit	Nesting habit	Foraging habit		St. Catharines	Port Colborne	Wainfleet
Haliictidae (54 species)							
<i>*Agapostemon (Agapostemon) texanus</i> Cresson	Solitary	Ground	Generalist	Native	X		
<i>Agapostemon (Agapostemon) virescens</i> (Fabricius)	Communal	Ground	Generalist	Native	X	X	X
<i>Augochlora (Augochlora) pura</i> (Say)	Solitary	Wood	Generalist	Native	X	X	X
<i>Augochlorella aurata</i> (Smith)	Eusocial	Ground	Generalist	Native	X	X	X
<i>Augochloropsis (Paraugochloropsis) metallica</i> (Fabricius)	Semisoocial?	Ground	Generalist	Native	X		
<i>Dufourea monardae</i> (Viereck)	Solitary	Ground	<i>Monarda</i> Linnaeus	Native	X		
<i>Haliictus (Odonalictus) litigatus</i> Say	Eusocial	Ground	(Lamiaceae) Generalist	Native	X	X	X
<i>Haliictus (Protohaliictus) rubicundus</i> (Christ)	Solitary/eusocial	Ground	Generalist	Native	X	X	X
<i>Haliictus (Seladonia) confusus</i> Smith	Solitary/eusocial	Ground	Generalist	Native	X	X	X
<i>Lasioglossum (Dialictus) admirandum</i> (Sandhouse)	Eusocial?	Ground	Generalist	Native	X	X	X
<i>Lasioglossum (Dialictus) albipenne</i> (Robertson)	Eusocial?	Ground	Generalist	Native	X		
<i>Lasioglossum (Dialictus) atwoodi</i> Gibbs	Eusocial?	Ground	Generalist	Native	X	X	X
<i>Lasioglossum (Dialictus) coeruleum</i> (Robertson)	Eusocial	Wood	Generalist	Native	X		
<i>Lasioglossum (Dialictus) cressonii</i> (Robertson)	Eusocial?	Wood	Generalist	Native	X	X	X
<i>Lasioglossum (Dialictus) dreisbachi</i> (Mitchell)	Unknown	Unknown	<i>Salix</i> Linnaeus	Native	X		
<i>Lasioglossum (Dialictus) ellisiae</i> (Sandhouse)	Eusocial?	Ground	(Salicaceae) Generalist	Native	X		
<i>Lasioglossum (Dialictus) ephialtum</i> Gibbs	Eusocial?	Ground	Generalist	Native	X	X	X

TABLE 1 continued...

Family and species	Life History trait			Origin	Municipality		
	Social habit	Nesting habit	Foraging habit		St. Catharines	Port Colborne	Wainfleet
<i>Lasioslossum (Dialictus) fattigi</i> (Mitchell)	Eusocial?	Ground	Generalist	Native	X	X	
* <i>Lasioslossum (Dialictus) furunculum</i> Gibbs	Clepto- or social parasite	Nests of nest-building <i>Dialictus?</i> Ground	N/A	Native	X		
<i>Lasioslossum (Dialictus) hitchensi</i> Gibbs	Eusocial?	Ground	Generalist	Native	X	X	X
<i>Lasioslossum (Dialictus) imitatum</i> (Smith)	Eusocial	Ground	Generalist	Native	X	X	X
<i>Lasioslossum (Dialictus) laevisimum</i> (Smith)	Eusocial	Ground	Generalist	Native	X	X	X
<i>Lasioslossum (Dialictus) leucomomum</i> (Lovell)	Eusocial?	Ground	Generalist	Native	X		X
<i>Lasioslossum (Dialictus) lineatum</i> (Crawford)	Eusocial	Ground	Generalist	Native	X		X
<i>Lasioslossum (Dialictus) lionotum</i> (Sandhouse)	Social parasite	Nests of <i>L.</i> <i>imitatum</i>	N/A	Native	X		
<i>Lasioslossum (Dialictus) michiganense</i> (Mitchell)	Clepto- or social parasite	Nests of nest-building <i>Dialictus?</i> Wood	N/A	Native	X		
<i>Lasioslossum (Dialictus) nigroviride</i> (Graenicher)	Eusocial?	Wood	Generalist	Native	X	X	
* <i>Lasioslossum (Dialictus) oblongum</i> (Lovell)	Unknown	Wood	Generalist	Native		X	X
<i>Lasioslossum (Dialictus) oceanicum</i> (Cockerell)	Eusocial?	Ground	Generalist	Native	X		
<i>Lasioslossum (Dialictus) paradmirandum</i> (Knerer and Atwood)	Eusocial?	Ground	Generalist	Native	X	X	X
<i>Lasioslossum (Dialictus) perpunctatum</i> (Ellis)	Eusocial?	Ground	Generalist	Native	X	X	
* <i>Lasioslossum (Dialictus) pilosum</i> (Smith)	Communal?	Ground	Generalist	Native			X
<i>Lasioslossum (Dialictus) planatum</i> (Lovell)	Eusocial?	Ground?	Generalist	Native	X		
* <i>Lasioslossum (Dialictus) platyparium</i> (Robertson)	Social parasite	Nests of nest-building <i>Dialictus?</i>	N/A	Native	X		

TABLE 1 continued...

Family and species	Life History trait			Origin	Municipality		
	Social habit	Nesting habit	Foraging habit		St. Catharines	Port Colborne	Wainfleet
<i>Lasioglossum (Dialictus) sagax</i> (Sandhouse)	Eusocial?	Ground	Generalist	Native	X	X	
<i>Lasioglossum (Dialictus) smilacinae</i> (Robertson)	Eusocial?	Ground	Generalist	Native	X		
* <i>Lasioglossum (Dialictus) subviridatum</i> (Cockerell)	Unknown	Wood	Generalist	Native	X		
* <i>Lasioglossum (Dialictus) versans</i> (Lovell)	Unknown	Ground	Generalist	Native	X		
<i>Lasioglossum (Dialictus) versatum</i> (Robertson)	Eusocial	Ground	Generalist	Native	X	X	X
<i>Lasioglossum (Dialictus) viridatum</i> (Lovell)	Eusocial	Ground	Generalist	Native	X	X	X
* <i>Lasioglossum (Dialictus) weemsi</i> (Mitchell)	Eusocial?	Ground?	Generalist?	Native	X	X	X
<i>Lasioglossum (Dialictus) zephyrum</i> (Smith)	Eusocial	Ground	Generalist	Native	X	X	X
<i>Lasioglossum (Evyllaenus) cincitipes</i> (Provancher)	Eusocial	Ground	Generalist	Native	X		
<i>Lasioglossum (Hemihalictus) foxii</i> (Robertson)	Solitary?	Ground	Generalist	Native	X		
<i>Lasioglossum (Hemihalictus) inconditum</i> (Cockerell)	Solitary?	Ground	Generalist	Native	X		
<i>Lasioglossum (Hemihalictus)</i> <i>macoupinense</i> (Robertson)	Solitary	Ground	Generalist	Native	X		
<i>Lasioglossum (Lasioglossum) cortaceum</i> (Smith)	Solitary	Ground	Generalist	Native	X	X	
<i>Lasioglossum (Leuchalictus) leucozonium</i> (Schrank)	Solitary	Ground	Generalist	Exotic	X	X	X
<i>Lasioglossum (Leuchalictus) zonulum</i> (Smith)	Solitary	Ground	Generalist	Exotic	X	X	X
* <i>Lasioglossum (Sphecodogastra)</i> <i>quebecense</i> (Crawford)	Solitary	Ground	Generalist	Native	X		
* <i>Sphecodes atlantis</i> Mitchell	Cleptoparasite	Nests of nest-building	N/A	Native	X	X	
<i>Lasioglossum</i>							

TABLE 1 continued...

Family and species	Life History trait		Origin	Municipality		
	Social habit	Nesting habit		Foraging habit	St. Catharines	Port Colborne
<i>Sphecodes dichrous</i> Smith	Cleptoparasite	Nests of nest-building <i>Halictus</i> and/or <i>Lasiglossum</i>	N/A	Native	X	
<i>Sphecodes heraclei</i> Robertson	Cleptoparasite	Nests of nest-building <i>Halictus</i> and/or <i>Lasiglossum</i>	N/A	Native	X	
<i>Sphecodes ranunculi</i> Robertson	Cleptoparasite	Nests of nest-building <i>Halictus</i> and/or <i>Lasiglossum</i>	N/A	Native	X	
Megachilidae (32 species)						
<i>Anthidiellum (Loyolanthidium) notatum</i> (Latreille)	Solitary	Makes nests on surfaces	Generalist	Native	X	
<i>Anthidium (Anthidium) manicatum</i> (Linnaeus)	Solitary	Cavities	Generalist	Exotic	X	X
* <i>Anthidium (Proanthidium) oblongatum</i> (Illiger)	Solitary	Cavities	Generalist	Exotic	X	
<i>Chelostoma (Cyrodromella) rapunculi</i> (Lepelletier)	Solitary	Cavities	<i>Campanula</i> Linnaeus	Exotic	X	
<i>Coelioxys (Boreocoelioxys) octodentata</i> Say	Cleptoparasite	Nests of <i>Megachile brevis</i> , <i>M. centuncularis</i> , and <i>M. mendica</i>	(Campanulaceae) N/A	Native	X	X

TABLE 1 continued...

Family and species	Life History trait			Origin	Municipality		
	Social habit	Nesting habit	Foraging habit		St. Catharines	Port Colborne	Wainfleet
<i>Coelioxys (Boreocoelioxys) rufitarsis</i> Smith	Cleptoparasite	Nests of <i>Megachile latimanus</i> and <i>M. melanophaea</i> Smith (not collected)	N/A	Native	X		
<i>Heriades (Neotrypetes) leavittii</i> Crawford	Solitary	Cavities	Generalist	Native	X		
<i>Heriades (Neotrypetes) variolosa</i> (Cresson)	Solitary	Cavities	Generalist	Native	X		
<i>Heriades (Neotrypetes) carinata</i> Cresson	Solitary	Cavities	Generalist	Native	X	X	
<i>Hoplitis (Alcidamea) pilosifrons</i> (Cresson)	Solitary	Cavities	Generalist	Native	X	X	X
<i>Hoplitis (Alcidamea) producta</i> (Cresson)	Solitary	Cavities	Generalist	Native	X	X	
<i>Hoplitis (Alcidamea) spoliata</i> (Provancher)	Solitary	Cavities	Generalist	Native	X	X	
* <i>Megachile (Callomegachile) sculpturalis</i> Smith	Solitary	Cavities	Generalist	Exotic	X		X
<i>Megachile (Chelostomoides) campanulae</i> (Robertson)	Solitary	Cavities	Generalist	Native	X		
<i>Megachile (Euricharaea) rotundata</i> (Fabricius)	Solitary	Cavities	Generalist	Exotic	X	X	X
<i>Megachile (Litomegachile) brevis</i> Say	Solitary	Cavities/ ground	Generalist	Native	X	X	X
<i>Megachile (Litomegachile) mendica</i> Cresson	Solitary	Cavities/ ground	Generalist	Native	X	X	
<i>Megachile (Litomegachile) texana</i> Cresson	Solitary	Ground	Generalist	Native	X		
<i>Megachile (Megachile) centuncularis</i> (Linnaeus)	Solitary	Cavities	Generalist	Possibly exotic	X	X	X
<i>Megachile (Megachile) relativa</i> Cresson	Solitary	Cavities	Generalist	Native	X		X
<i>Megachile (Pseudomegachile) ericetorum</i> Lepelletier	Solitary	Cavities	Generalist	Exotic	X	X	

TABLE 1 continued...

Family and species	Life History trait		Origin	Municipality		
	Social habit	Nesting habit		Foraging habit	St. Catharines	Port Colborne
<i>Megachile (Sayapis) pugnata</i> Say	Solitary	Cavities	Generalist	Native	X	
* <i>Megachile (Xanthosarus) frigida</i> Smith	Solitary	Wood	Generalist	Native	X	
* <i>Megachile (Xanthosarus) gemula</i> Cresson	Solitary	Ground	Generalist	Native	X	
<i>Megachile (Xanthosarus) latimanus</i> Say	Solitary	Ground	Generalist	Native	X	
<i>Osmia (Diceratomia) conjuncta</i> Cresson	Solitary	Snail shells	Generalist	Native	X	X
* <i>Osmia (Helicosmia) georgica</i> Cresson	Solitary	Wood	Asteraceae specialist	Native		X
<i>Osmia (Melanosmia) atriventris</i> Cresson	Solitary	Cavities	Generalist	Native	X	X
<i>Osmia (Melanosmia) pumila</i> Cresson	Solitary	Stems/cavities	Generalist	Native	X	X
<i>Osmia (Melanosmia) simillima</i> Smith	Solitary	Wood	Generalist	Native	X	
<i>Osmia (Osmia) lignaria</i> Say	Solitary	Cavities	Generalist	Native	X	
<i>Stelis (Stelis) lateralis</i> Cresson	Cleptoparasite	Nests of <i>Hoplitis pilosifrons</i> , <i>H. producta</i> , <i>H. simplex</i> (not collected)	N/A	Native	X	X

Notes:

- 1) The following species were listed under different names in Richards *et al.* (2011) (their taxonomy has since changed), with previous designations provided in parentheses: *Pseudopanurgus andrenoides* (*Protandrena andrenoides*), *Ceratina mikmaqi* (*Ceratina dupla* [in part]), *Nomada bidentata* group (Forms D, H, N, and O [in part]), *Lastioglossum hitchensi* (*Lastioglossum mitchelli* Gibbs), *Lastioglossum litorum* (*Lastioglossum asteris* (Mitchell)), *Lastioglossum smilacinae* (*Lastioglossum zophops* (Robertson)), *Lastioglossum inconditum* (*Lastioglossum rufitarse* (Zetterstedt)), *Lastioglossum macoupinense* (*Lastioglossum divergens* (Lovell)), *Heriades variolosa* (*Heriades variolus*), *Heriades carinata* (*Heriades carinatus*).
- 2) Bidentate species of *Nomada* are in need of revision, and those in our collection may include several undescribed species, but here we treat bidentate forms as a single morphospecies.
- 3) Life history information was taken from the following sources: Arduser (2002), Ascher (2001), Ascher *et al.* (2014), Bohart and Nye (1956), Bouseman and LaBerge (1978), Colla *et al.* (2011), Eickwort and Abrams (1980), Gibbs (2010, 2011), Gibbs *et al.* (2013), Gritti and Packer (2006), Hartman *et al.* (1944), LaBerge (1973, 1980, 1985, 1987, 1989), LaBerge and Ribble (1972, 1975), Michener (2007), Mitchell (1960, 1962), Osgood (1989), Packer *et al.* (2007), Ribble (1967, 1974), Richards *et al.* (2011), Rightmyer (2008), Roberts (1973), Sheffield *et al.* (2010, 2011a, 2011b, 2014), Stockhammer (1967), Taraday (1982), and Wolf and Ascher (2009).

We collected a single female specimen of *L. furunculum* on 9 September 2009 from St. Catharines on the periphery of the Glenridge Quarry Naturalization Site, just south of the Niagara Escarpment. Males of the species are unknown (Gibbs 2011). Given the similarity of this species to *L. izawsum*, the lack of DNA barcodes, and the limited number of individuals available for both species, it is possible that *L. furunculum* and *L. izawsum* are synonymous (Gibbs 2011). However, the two species are currently recognized as valid, and the St. Catharines specimen best matches the description of *L. furunculum*. The species is presumably a cleptoparasite or a social parasite of one or more of the nest-building *Lasioglossum* (*Dialictus*) species present at our St. Catharines sites.

Discussion

Observed morphospecies richness of the entire 10-year sample from the St. Catharines sites (147 species) effectively matched that predicted by the abundance-based coverage (ACE, 147 species) and Chao1 estimators (mean \pm SD = 145 \pm 9.6) based on combined pan-trap, sweep-net, and flower-net collection data from 2003 (Richards *et al.* 2011). Only three species present in Port Colborne and Wainfleet were entirely absent in samples from St. Catharines; these were *Lasioglossum oblongum* (Lovell) (Hymenoptera: Halictidae), *Lasioglossum pilosum* (Smith) (Hymenoptera: Halictidae), and *Osmia georgica* Cresson (Hymenoptera: Megachilidae). We collected far more species and morphospecies in St. Catharines (147) than in Port Colborne (64) and Wainfleet (61) (Table 1), which was expected since St. Catharines samples were collected for 10 years and in relatively undisturbed as well as regenerating sites.

The current list undoubtedly reflects some biases in the sampling protocols used, and there are certain taxa that appear to be underrepresented in terms of diversity, or should be present given records in areas neighbouring the Niagara Peninsula but are entirely absent

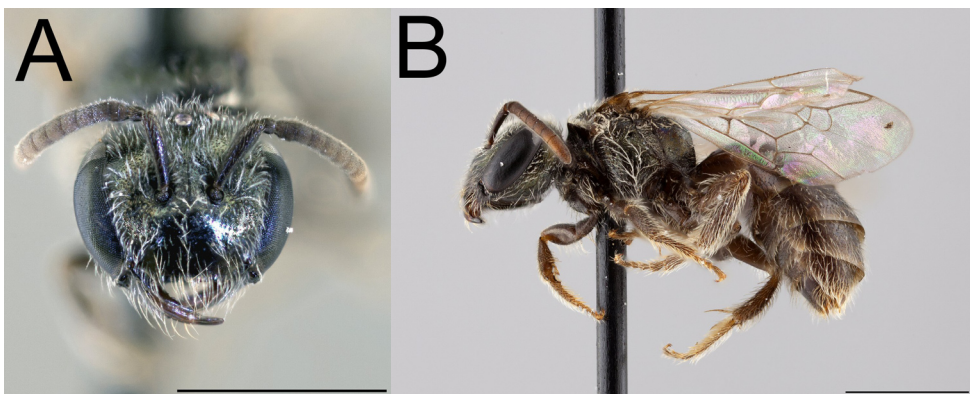


FIGURE 1: Face (A) and lateral view (B) of a female specimen of *Lasioglossum furunculum* Gibbs collected in southern St. Catharines in 2009. Note the absence of a preapical tooth on the mandible and narrow gena in lateral view. Scale bars = 1 mm.

from our samples. We never sampled from trees or tall shrubs, so the species presented here likely reflect a large subsample of the resident bee communities that forages at or near ground level. This might explain the comparatively low diversity of the genus *Andrena*, which frequently visit spring blooming trees and include multiple specialists of willows and other spring blooming plants. Given that pan-trapping was the main sampling method employed among years, it is not surprising that in our samples *Colletes* Latreille (Hymenoptera: Colletidae), a genus usually sampled very well in nets, not pans (Wilson *et al.* 2008), were low in both number and diversity. Forty bee genera occur in southern Ontario (Packer *et al.* 2007; Gibbs *et al.* 2014), and several of these (*Dieunomia* Cockerell (Hymenoptera: Halictidae), *Dianthidium* Cockerell (Hymenoptera: Megachilidae), *Paranthidium* Cockerell and Cockerell (Hymenoptera: Megachilidae), *Epeoloides* Giraud (Hymenoptera: Apidae), *Macropis* Panzer (Hymenoptera: Melittidae), and *Svastra* Holmberg (Hymenoptera: Apidae)) are too rare or transient to be expected in our sites. The melittid genus *Macropis* ranges from Nova Scotia to Washington and south to Georgia (Hurd 1979) and collects floral oils from loosestrife (*Lysimachia* Linnaeus (Primulaceae) (Cane *et al.* 1983), which was rare in our study sites. Some bees like *Peponapis pruinosa* (Say) (Hymenoptera: Apidae) are expected to be relatively common in the Niagara Region, but this species is restricted to areas where cultivated cucurbits, *Cucurbita* Linnaeus (Cucurbitaceae), are present. *Perdita* Smith (Hymenoptera: Andrenidae), another genus that should be present in our region, is largely composed of small, floral specialists. *Holcopasites* Ashmead (Hymenoptera: Apidae), absent from our collections, are small cleptoparasites of *Calliopsis*; the latter was uncommon in our sites. *Epeolus* Latreille (Hymenoptera: Apidae), a genus of cleptoparasites of *Colletes*, was absent from our samples, although over half a dozen species are known from southern Ontario, including two species recorded from Port Colborne (Romankova 2004). Cleptoparasite and social parasite diversity overall may have been underrepresented in our collections. Our main method of sampling, pan trapping, likely biases collection toward small sweat bees (Halictidae), and underrepresents parasitic species, which spend more time searching for host nests than foraging, and larger bee species that can crawl out of pan traps should they fall in inadvertently (Cane *et al.* 2000; Wilson *et al.* 2008). A study by Cane *et al.* 2000 demonstrated that pan traps failed to catch most species of floral specialists associated with the creosote-bush, *Larrea tridentata* (DC.) Coville (Zygophyllaceae), below which the traps were set. The few specialist species present in our collections were mainly sampled from flowers or sweeps through vegetation.

The number of species found in the present study is lower than that known from the Caledon Hills, located north and east of the Niagara Escarpment and close to the eastern limit of the Carolinian Zone in Ontario. Between two surveys there, one by MacKay and Knerer (1979) in 1968–1969 and another by Gixti and Packer (2006) in 2002–2003, 165 species were recorded, excluding honey bee, *Apis mellifera* Linnaeus (Apidae), and bumble bees, *Bombus* Latreille (Apidae), which were not sampled. Bee surveys taken between 1957 and 1984 at an abandoned field bordering forests comprised of oak, *Quercus* Linnaeus (Fagaceae) and hickory, *Carya* Nuttall (Juglandaceae), (also within the eastern deciduous-Carolinian forest region) at the Edwin S. George Reserve in Livingston County, Michigan, United States of America, yielded a similar number of species (172) (Evans 1986). Given the longer species lists from these similar studies and factors related to sampling, it is likely that at least some additional species occur within or near our study areas, and still more

within the greater Niagara Region.

Exotic species ranged from well-established introductions such as *A. mellifera* and *Megachile rotundata* (Fabricius) (Hymenoptera: Megachilidae) to more recent colonists (Table 1). The Palaearctic leafcutter bee *Megachile ericetorum* Lepeletier (Hymenoptera: Megachilidae), first discovered in the New World in St. Catharines in 2003 (Sheffield *et al.* 2010), is now well-established in the Niagara Region, based on subsequent captures of more than a dozen individuals in St. Catharines in 2006, 2010, 2012, and 2013 and in Port Colborne in 2012 and 2013; and recently in Rochester, New York, United States of America (Jacobi and Stafford 2012). We also collected two introduced *Hylaeus* species of the subgenus *Spatulariella*. *Hylaeus hyalinatus* Smith (Hymenoptera: Colletidae) was first reported in North America in 2001 (Ascher 2001) and then in St. Catharines almost every year from 2003 (Richards *et al.* 2011) to 2013, and was also found in Wainfleet in 2012. *Hylaeus punctatus* (Brullé) (Hymenoptera: Colletidae) was first recorded in Canada in 2011 by Sheffield *et al.* (2011a), and was subsequently discovered in our St. Catharines samples from the same year. *Anthidium manicatum* (Linnaeus) (Hymenoptera: Megachilidae), which was found in almost every sampling year in St. Catharines, was also found in Pt. Colborne and Wainfleet. We also sampled a related introduced species, *Anthidium oblongatum* (Illiger) (Hymenoptera: Megachilidae), which is Palaearctic in origin and has been in Ontario since at least 2002 (Sheffield *et al.* 2011a). Exotic species established in eastern North America for some time include *Lasioglossum leucozonium* (Schrank) (Hymenoptera: Halictidae), *L. zonulum* (Smith) (Hymenoptera: Halictidae) (our only members of the subgenus *Leuchalictus*) (Giles and Ascher 2006), *Chelostoma rapunculi* (Lepeletier) (Hymenoptera: Megachilidae) (Buck *et al.* 2005), and *Megachile sculpturalis* Smith (Hymenoptera: Megachilidae) (Paiero and Buck 2003). The leafcutter bee *Megachile centuncularis* (Linnaeus) (Hymenoptera: Megachilidae) has traditionally been considered to be a Holarctic species, though now there may be reason to suspect that it is exotic in North America as well (Giles and Ascher 2006; Sheffield *et al.* 2011b). Additional collections after 2003 of some of the abovementioned exotic species in the Niagara Peninsula may be indicative of their establishment within Ontario. Continued surveying within the present study region may be important in detecting future introductions as southern Ontario seems to have the highest number of introduced bee species in Canada (16 out of 17 exotic species in Canada (Sheffield *et al.* 2011b)), with one first record for North America of an Old World species discovered in St. Catharines.

Our 10 years of collections represent the most extensive survey of the bee fauna in the Niagara Peninsula to date, and to our knowledge this is the longest continuous survey of any regional bee fauna in Canada. Although rare, transient, or extremely localized species may be discovered in the future, the current list likely encompasses the majority of common species present within the three sampled municipalities. To better detect the regional distribution patterns of bees, comprehensive sampling at additional localities is needed.

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