

HYLAEUS PUNCTATUS (HYMENOPTERA: COLLETIDAE), A BEE SPECIES NEW TO CANADA, WITH NOTES ON OTHER NON-NATIVE SPECIES

C. S. SHEFFIELD¹, S. DUMESH, AND M. CHERYOMINA

Department of Biology, York University,
4700 Keele Street, Toronto, ON, Canada M3J 1P3
email: cory.silas.sheffield@gmail.com

Abstract

J. ent. Soc. Ont. 142: 29–43

Hylaeus punctatus (Brullé) (Colletidae; Hylaeinae), the second species of the Old World subgenus *Spatulariella* recorded in the Western Hemisphere, is reported in Canada for the first time. A diagnosis for recognizing the subgenus among the Canadian fauna and a key to distinguish the two species are provided. Additionally, we provide a brief summary of non-native bee species in Canada.

Published December 2011

Introduction

A recent “General Status of Species in Canada” assessment for Canadian bee species compiled 803 species, with the highest diversity in southern areas bordering the United States (Canadian Endangered Species Conservation Council, in preparation). New bee species are still being described in Canada (Gibbs 2010; Rehan and Sheffield 2011), and new distributional records are frequently being added (Gibbs 2010; Dumesh and Sheffield in press; Sheffield et al. in press), most of these as northern range extensions from the adjacent United States. Areas of Canada bordering the United States are thus particularly important in terms of receiving and/or intercepting non-native species (Cane 2003; Sheffield et al. 2010).

Introduced species are considered among the greatest threats to local biodiversity (Wilson 1999; Chivian and Bernstein 2008). Therefore, noting the presence and time of establishment of non-native insects, including bees, within a region is critical to monitor effectively the potential impact of these species on the indigenous fauna (Cane 2003; Sheffield et al. 2010). It is also important to understand the biology of these species, including, for bees, establishing their patterns of floral use and nesting-site preferences. Many introduced species share floral resources and compete for nesting sites with native species (Barthell et al. 1998), especially in urban settings (Matteson et al. 2008). Such data are also important for developing predictive models to determine the likely range of suitable

¹Author to whom all correspondence should be addressed.

habitat and ultimate distribution (Hinojosa-Díaz et al. 2005; Strange et al. 2011). In the last few decades, several Old World bee species have been recorded for the first time in Canada, from Ontario (Smith 1991; Paiero and Buck 2004; Buck et al. 2006; Sheffield et al. 2010), most of which have subsequently established populations.

Here, we report a non-native species, *Hylaeus* (*Spatulariella*) *punctatus* (Brullé) in Canada. This species is one of two *H.* (*Spatulariella*) species now established in North America (Ascher 2001; Ascher et al. 2006; Tonietto and Ascher 2008). We give a diagnosis of the subgenus and provide a key to the two species of *H.* (*Spatulariella*) known to be present in North America. Additionally, we provide a summary of the other 16 non-native bee species in Canada.

Results

First records of a new exotic species in Canada

***Hylaeus* (*Spatulariella*) *punctatus* (Brullé).** *Hylaeus punctatus* was first collected in North America in 1981 at Playa del Rey, Los Angeles Co., California (Snelling 1983) and, shortly after, recorded in South America at Santiago, Chile (Toro et al. 1989). More recently, it was discovered further east in North America, first from the District of Columbia (Ascher et al. 2006), and later in New York (Matteson et al. 2008) and Colorado (Ascher and Pickering 2011). We collected fourteen specimens, deposited in the Packer Collection, York University (PCYU) and the Canadian National Collection of Insects, Arachnids and Nematodes (CNC), with the following data: CANADA. Ontario: Toronto, York University campus, 43.7753°N 79.5056°W, 196m, 27.vii.2011, S. Dumes, M. Cheryomina, C. Sheffield (9♂); same locality, 29.vii.2011, C. Sheffield (5♂) and 30.vii.2011, C. Sheffield (1♀). All specimens were collected on wild carrot, *Daucus carota* L. (Apiaceae). In sweeps of these plants, 44% of the *Hylaeus* captured were males of *H.* (*Spatulariella*): *H. hyalinatus* 26% and *H. punctatus* 18%. Gosek et al. (1995) suggested *H. punctatus* as a potential pollinator of carrot; this affinity may be useful for monitoring its further spread in North America. The lack of distributional data between western locations, i.e., California, Colorado, and eastern North America may represent multiple introductions and/or lack of detection due to “no” sampling. *Hylaeus punctatus* probably nests in pre-existing cavities (Westrich 1990), which likely facilitated its arrival into North America (Ascher 2001) and subsequent spread.

The arrival of *H. punctatus* in Canada appears to be recent, as pan trap surveys on York University campus between 2004 and 2006 (Colla et al. 2009) failed to detect it (or *H. hyalinatus*) among the 248 specimens of *Hylaeus* collected. Neither species was collected in the 2002-2003 survey of Grixti and Packer (2006) approximately 20 km northeast of York University campus, though other surveys in southern Ontario have detected *H. hyalinatus* in low numbers: in 2003 in St. Catharines, Ontario, only two *H. hyalinatus* were collected among 1729 *Hylaeus* specimens (Richards et al. 2011). In a survey in Hamilton (Royal Botanic Gardens) 6 out of 112 *Hylaeus* specimens were *H. hyalinatus* (Andrachuk, unpublished). However, the numbers of *H. punctatus* recorded here may suggest that this species has been in Ontario for several years, though undetected, as very few have been caught in pan traps relative to indigenous species (Colla et al., 2009; Richards et al. 2011;

Andrachuk, unpublished), despite the subgenus being proportionally very abundant on *Daucus* florets.

Diagnosis and key to species of *Hylaeus* (*Spatulariella*) in North America.

The subgenus is distinguished from other North American *Hylaeus* subgenera by the presence of a lamelliform carina between anterior and lateral faces of the mesepisternum in both sexes (Figures 1a, 1c; easiest to see in ventrolateral view), which is absent in the other subgenera found in Canada (Figures 1b, 1d). Males of this subgenus are further distinguished by the spatulate apex of sternum 8 (Figure 5a), which often protrudes from the genital opening.

The following key (modified from Ascher 2001) can be used to distinguish the two species of *H. (Spatulariella)* in North America, and can be used with Mitchell (1960) and Romankova (2007) for identifying species in eastern Canada.

1	Females.....	2
	Males.....	3
2(1)	Face with long lateral maculations that fill most of the lower paraocular area (Figure 2a); mesopleuron with distinct shining interspaces among the punctures (Figure 3a), the punctures similar in size to those on the mesoscutum (Figure 3c), especially anterior to episternal groove (Figure 3a).....	<i>H. hyalinatus</i> Smith
–	Face with lateral maculations reduced (Figure 2c); mesopleuron more coarsely and closely punctate, without shining interspaces among the punctures (Figure 3b), the punctures generally larger and deeper than those on the mesoscutum (Figure 3d).....	<i>H. punctatus</i> (Brullé)
3(1)	Sternum 8 with distal spatulate process rounded apically, connected to the base by an extremely narrow elongate stalk (Figure 5a); face with extensive yellow maculation, the supraclypeal area nearly entirely pale, with lateral face marks extending on the eye margin to well above antennal base (Figure 2b); pleura with distinct shining interspaces among the punctures (Figure 4a), the punctures similar in size to those on mesoscutum (Figure 4c).....	<i>H. hyalinatus</i> Smith
–	Sternum 8 with distal process bi-lobed (emarginated apically), connected to the base by a broad stalk (Figure 5b); face with pale maculations less extensive, supraclypeal area black (Figure 3d) or with yellow band restricted to apical half (Figures 3e and 3f), lateral face marks reduced and seldom extending above epistomal sulcus (Figure 3d-3f); pleura more coarsely and closely punctate, without shining interspaces among the punctures (Figure 4b), the punctures generally wider and deeper than those on mesoscutum (Figure 4d).....	<i>H. punctatus</i> (Brullé)

Notes on other exotic bee species in Canada

COLLETIDAE

H. (Spatulariella) hyalinatus Smith. This European species (also discussed above) was first reported in North American in 2001 (Ascher 2001) from collections made between

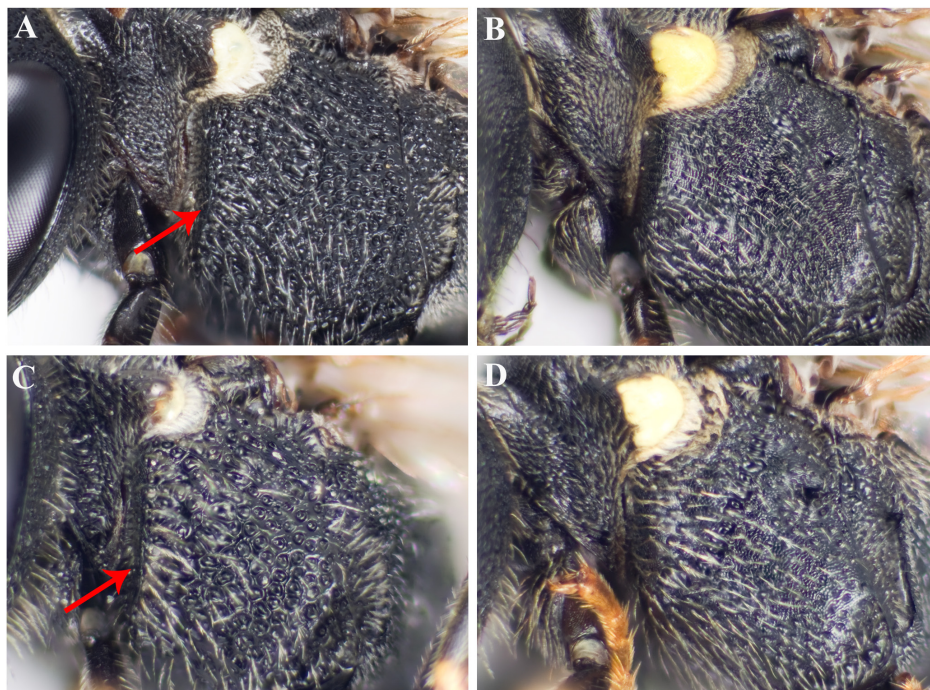


FIGURE 1. Distinguishing characteristic of *Hylaeus* (*Spatulariella*). Female (A) and male (C) of *H. (Spatulariella)* with visible lamelliiform carina extending from pronotal lobe to forecoxa. Female (B) and male (D) of *Hylaeus (Prosopis)* without visible carina.

1997 and 2000 in New York. It was reported in southern Ontario shortly after (Buck et al. 2006), though the material examined in that study suggested it has been in North America (Canada) since 1993. It is a cavity-nesting species (Ascher 2001).

***Hylaeus leptocephalus* (Morawitz).** Snelling (1970) indicated that this cavity-nesting species (as *H. stevensi* (Crawford)) was not closely related to any *Hylaeus* in the Nearctic region, and was virtually identical to the Palearctic *H. bisinuatus* Förster. Both are now considered synonyms of *H. leptocephalus*. This common species is found throughout the United States and southern Canada (British Columbia-Nova Scotia), and is possibly an oligolege of *Melilotus*, also introduced from the Palearctic region (Snelling 1970; but listed as polylectic by Cane (2003)). *Hylaeus leptocephalus* has been in North America since 1912 (collected in Fargo, North Dakota), and was first collected in Canada (Alberta) in 1916 (Snelling 1970).

ANDRENIDAE

***Andrena wilkella* (Kirby).** This species occurs naturally in Europe and northern Asia, and is now common throughout northeastern North America. *Andrena wilkella* has been in North America since the 1800s (Malloch 1918) and, like the other ground-nesting species

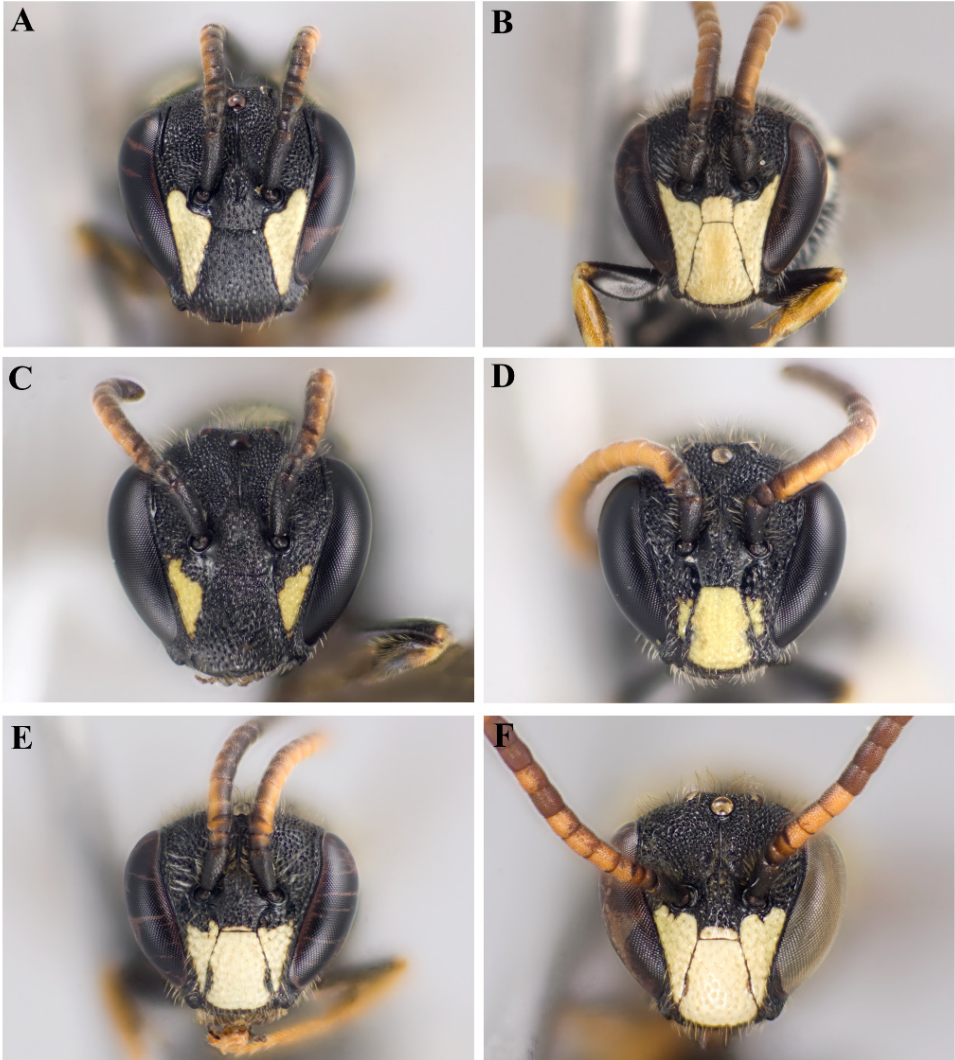


FIGURE 2. Facial maculation patterns of *Hylaeus* (*Spatulariella*) in North America. Female (A) and male (B) of *H. hyalinatus*. Female (C) and male (D–F) of *H. punctatus*; D–F show variation in males of *H. punctatus*, ranging from no maculation on supraclypeal area and reduced maculation on lower paraocular area (D) to a band on apical 1/4 (E) to 1/2 (F) of supraclypeal area and more extensive maculation on lower paraocular area.

discussed below, it may have arrived in the New World through the importation and release of dry ballast, e.g., rock, sand, soil (Giles and Ascher 2006; Sheffield et al. 2010).

HALICTIDAE

***Lasioglossum leucozonium* (Schränk).** This ground-nesting species occurs naturally in Europe and northern China, and probably has been in North America since the 1800s (Droege 2008). *Lasioglossum leucozonium* was recently collected in Alberta (specimens in PCYU), well outside the range reported by McGinley (1986). More sampling in locations between the documented range given in McGinley (1986) and these western records is required to know the full extent of its distribution in North America.

***Lasioglossum zonulum* (Smith).** This “Holarctic” species (McGinley 1986) is also believed to be introduced (Giles and Ascher 2006) due to its phylogenetic position in the Old World *leucozonium* species group (Packer 1998; Danforth and Ji 2001). *Lasioglossum zonulum* has been in Canada since at least the mid-1800s, previously identified by Provancher (1882) as *Halictus discus* Smith (as *L. discus*) (Sheffield and Perron, unpublished). Though the

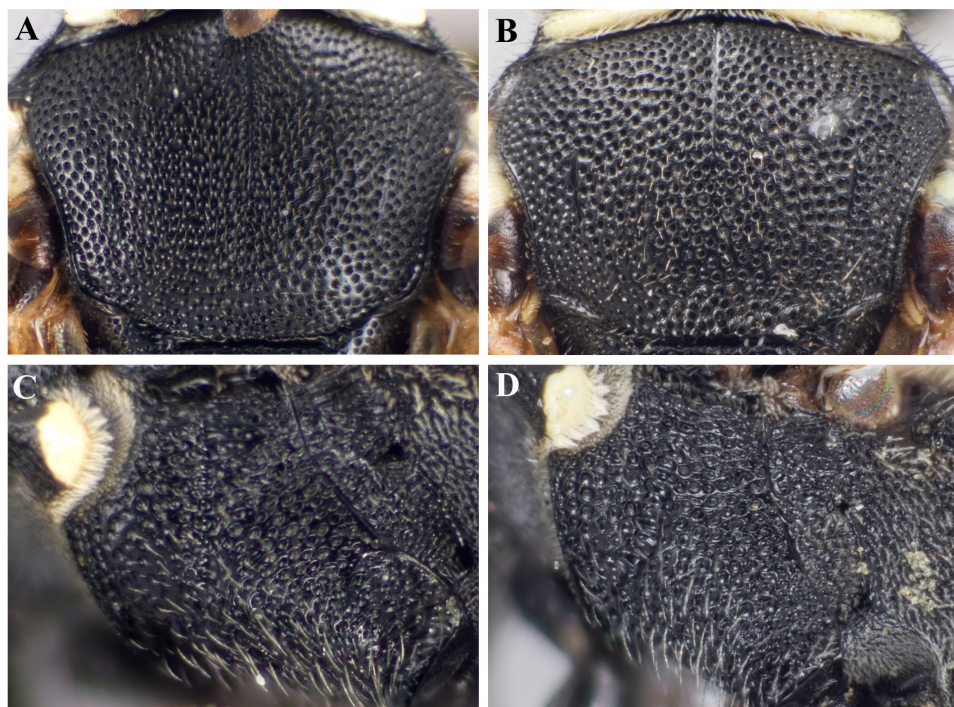


FIGURE 3. Distinguishing characters for females of *Hylaeus* (*Spatulariella*) in North America. Mesoscutum of female (A) *H. hyalinatus*, and (B) *H. punctatus*; mesopleuron of female (C) *H. hyalinatus*, and (D) *H. punctatus*.

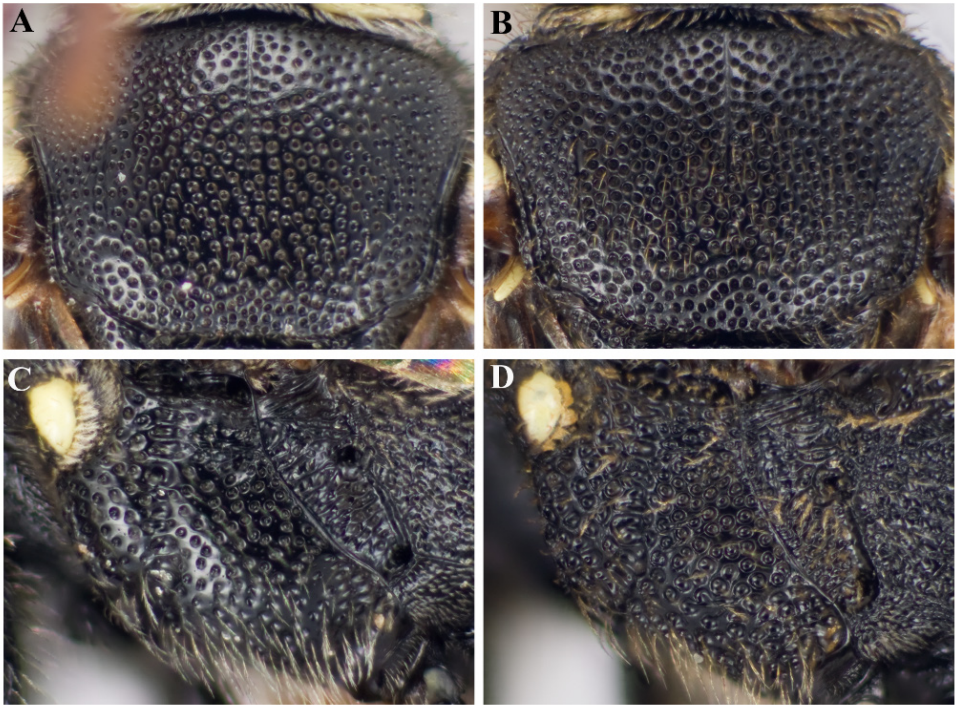


FIGURE 4. Distinguishing characters of male *Hylaeus* (*Spatulariella*) in North America. Mesoscutum of male (A) *H. hyalinatus*, and (B) *H. punctatus*; mesopleuron of male (C) *H. hyalinatus*, and (D) *H. punctatus*.

female of *Halictus discus* was described from “North America” this is believed to be an error (Mitchell 1960; Ebmer 1976).

MEGACHILIDAE

***Anthidium oblongatum* (Illiger).** A series of *Anthidium oblongatum* was collected in Toronto at York University campus in 2011 [col. C.S. Sheffield]. Most bees visiting *Lotus corniculatus* L. on campus are this species and the non-native *Megachile rotundata*, suggesting it is well established in Ontario. This species, native to Europe and the Near East, has been in Ontario since at least 2002 when three individuals were recorded by Romankova (2003). *Anthidium oblongatum* is well established in the eastern United States (Miller et al. 2002; Tonietto and Ascher 2008; Maier 2009) since it was first discovered in New York in 1994 (Hoebeker and Wheeler 1999). Miller et al. (2002) provide a key that can be used to recognize the species in eastern Canada. It is a cavity nesting species.

***Anthidium manicatum* (Linnaeus).** This species, native to Europe, North Africa, and the Near East (Banaszak and Romasenko 1998) was first discovered in North America in the



FIGURE 5. Distinguishing terminalia characters of males *Hylaeus* (*Spatulariella*) in North America. (A) *H. hyalinatus* S8, stalk narrow and apex rounded, (B) *H. punctatus* S8, stalk broad and apex emarginated or bilobed.

1960s (Jaycox 1967) and first reported in Canada (Ontario) in 1991 (Smith 1991). *Anthidium manicatum* is now well established and rapidly expanding its distribution throughout North America (Gibbs and Sheffield 2009; Maier 2009) and in 2011 was found on the island of Newfoundland (Barry Hicks, pers. comm.), within the likely range of establishment predicted by Strange et al. (2011). It is considered polylectic (Banaszak and Romasenko 1998) though commonly found associated with large urban and suburban gardens, particularly those with *Stachys* (Lamiaceae). It nests in cavities.

***Chelostoma campanularum* (Kirby).** Although only recently recorded in Canada, this cavity-nesting species has been here since at least 1976 (Buck et al. 2006), and is relatively common in Ontario in the cities of Guelph, St. Catharines, and Toronto. It occurs naturally in Europe and the Near East, and was first detected in North America in New York in the early 1970s (Eickwort 1980). The species is oligolectic on *Campanula* (Campanulaceae).

***Chelostoma rapunculi* (Lepeletier).** Like the preceding species, *C. rapunculi* is a cavity-nesting species introduced from the Palearctic region. It was first recorded in North America by Eickwort (1980), who examined specimens collected in New York from the early as 1960s. Females are also oligolectic on *Campanula*, though Buck et al. (2006) collected specimens on *Echium vulgare* L. (Boraginaceae).

***Hoplitis anthocopoides* (Schenck).** Like the preceding two species, *H. anthocopoides* is from Europe and was first detected in North America in Albany County, New York, in 1969 (Eickwort 1970), though not collected in Canada until 2002 (Buck et al. 2006). As a reported floral specialist, its spread in North America may be linked to localized availability and population connectivity of its food plant, *Echium vulgare*. Eickwort (1975) gave detailed accounts of its biology. This species, unlike most of the other non-native megachilid bees presented here, is a true mason bee, building its nests from “mortar and pebbles”. Because the nests are constructed on exposed areas of rocks, its mode of introduction into North America would presumably have been on exposed surfaces, not hidden in pre-existing cavities in wood, etc.

***Osmia caerulea* (Linnaeus).** This is probably our first established cavity-nesting bee species, arriving in North America in the 1800s. It occurs naturally throughout Europe, North Africa, the Near East and India (Rust 1974). In North America, this species is found primarily in northeastern and north central US and southeastern Canada to Nova Scotia (Rust 1974; Sheffield et al. 2003; 2008), though specimens have also been collected in British Columbia (specimens in PCYU) and in the north western United States (Cane 2003).

***Megachile (Eutricharaea) apicalis* Spinola.** This species is of Eurasian origin and was first reported as established in western North America by Cooper (1984). *Megachile apicalis* was only recently reported in Canada, collected in British Columbia in 2009 by Lincoln R. Best (Sheffield et al. in press), though it has recently been found in the eastern United States (S. Droege, pers. comm).

***Megachile (Eutricharaea) rotundata* (Fabricius).** This species, also of Eurasian origin, has been established in western Canada for at least 50–60 years, and has been developed extensively as a commercial pollinator of alfalfa (Pitts-Singer and Cane 2011). *Megachile rotundata* has been found in eastern Canada since the 1990s as a result of deliberate introductions for lowbush blueberry (*Vaccinium angustifolium* Aiton) (Ericaceae) pollination. Sheffield (2008) and Sheffield et al. (2008) suggested that this species may have established in Nova Scotia prior to this, possibly due to pollination trials of forage crops in the 1970s and 1980s.

***Megachile (Callomegachile) sculpturalis* Smith.** This species, from eastern Asia, was first detected in North America in North Carolina in 1994 (Magnum and Brooks 1997). *Megachile sculpturalis* was first observed in Canada (Ontario) in 2002 (Magnum and Sumner 2003; Paiero and Buck 2004), and was recently collected in Quebec (Gibbs and Sheffield 2009). This species has great potential to spread throughout the continent (Hinojosa-Díaz et al. 2005; Maier 2009).

***Megachile (Pseudomegachile) ericetorum* Lepeletier.** This species is wide-ranging in the Western Palearctic region, and has been in Canada at least since 2003 (Sheffield et al. 2010). It is currently known in North America only from a single female specimen collected on the Niagara Escarpment in St. Catharines, Ontario (Sheffield et al. 2010).

Apis mellifera L. This is the first bee species introduced into the Western Hemisphere, and the only bee species introduced intentionally into Canada. European settlers brought honey bees with them in the 1620s (Crane 1999; Horn 2005) for honey and wax production. These roles are now overshadowed in importance by crop pollination by *A. mellifera* throughout the world (Free 1993). It occurs from coast to coast in Canada, in all provinces and territories. Feral colonies are present throughout North America (including southern Canada), though numbers and persistence have declined since the arrival of parasitic mites in the last few decades (Droege 2008).

Conclusions

Major commodity entry points into Canada serve as likely entrance points for exotic species (Majka and LeSage 2006), including bees (Cane 2003; Sheffield et al. 2010). Ontario is one of the main entrance points for access so it is not surprising that all but one of the 17 exotic bee species in Canada are found in the province (Figure 6), and most of the

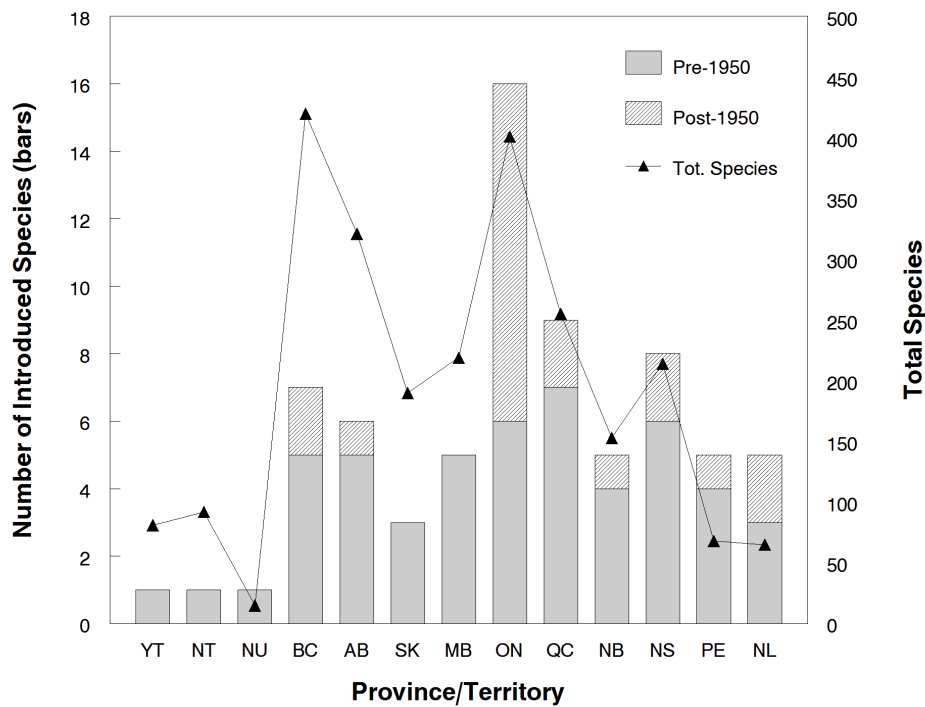


FIGURE 6. The number of introduced bee species occurring in each province or territory in Canada. Line with triangles represents total number of bee species known from each province or territory. Solid bars indicate species introduced to Canada pre-1950; cross-hatched bars represent post-1950 introductions.

post-1950s detections were first reported here (Smith 1991; Paiero and Buck 2004; Buck et al. 2006; Sheffield et al. 2010). An additional species, *Megachile xylocopoides* Smith, obtained from wood containing its mature larvae was recently intercepted at the Canadian border in Ontario (Hume Douglas, CFIA Ottawa, pers. comm.). Its identity was confirmed by DNA barcoding of larval tissue, and subsequent rearing. It is not established in Canada. As twelve of the 17 exotic bee species in Canada are cavity nesters, and specimens are sporadically intercepted at the Canadian border and at international entry points in the United States (Cane 2003), the likelihood of new arrivals is quite high. It is certainly worthwhile monitoring areas adjacent to the United States border because several additional non-native species are established in New York and adjacent areas of north eastern North America (Droege 2008; pers. comm.) and are likely spreading northward. Southern Ontario is likely to continue being the first region of arrival and detection of non-native bee species in Canada.

Acknowledgements

We thank Rémi Hébert (Canadian Wildlife Service, Environment Canada) for encouraging and facilitating the bee work for the General Status of Species in Canada, Sam Droege (United States Geological Survey) for helpful comments, correspondence, and continued hard work on bees in North America. Thanks also to Laurence Packer (York University) for helpful comments. We also acknowledge the contribution of the Ontario Research Fund (ORF) and Canadian Foundation for Innovation (CFI) for imaging equipment and support. This work was conducted during a research associate position to Cory Sheffield, funded by the NSERC-CANPOLIN (Canadian Pollination Initiative); Sheila Dumesh was funded through an NSERC Discovery Grant to Laurence Packer, York University. This is contribution number 32 of the Canadian Pollination Initiative.

References

- Ascher, J. S. 2001. *Hylaeus hyalinatus* Smith, a European bee new to North America, with notes on other adventive bees (Hymenoptera: Apoidea). Proceedings of the Entomological Society of Washington 103: 184–190.
- Ascher, J. S. and Pickering, J. 2011. Discover Life's bee species guide and world checklist. (http://www.discoverlife.org/mp/20q?guide=Apoidea_species&flags=HAS.)
- Ascher, J. S., Gambino, P. and Droege, S. 2006. Adventive *Hylaeus* (*Spatulariella*) Popov in the new world (Hymenoptera: Apoidea: Colletidae). Proceedings of the Entomological Society of Washington 108: 237–239.
- Banaszak, J. and Romasenko, L. 1998. Megachilid bees of Europe (Hymenoptera, Apoidea, Megachilidae). Pedagogical University of Bydgoszcz, Poland. 239 pp.
- Barthell, J. F., Frankie, G. W. and Thorp, R. W. 1998. Invader effects in a community of cavity nesting megachilid bees (Hymenoptera: Megachilidae). Environmental Entomology 27: 240–247.

- Buck, M., Paiero, S. M. and Marshall, S. A. 2006 [2005]. New records of native and introduced Aculeate Hymenoptera from Ontario, with keys to Eastern Canadian species of *Cerceris* (Crabronidae) and eastern Nearctic species of *Chelostoma* (Megachilidae). *Journal of the Entomological Society of Ontario* 136: 37–52.
- Canadian Endangered Species Conservation Council. Wild Species 2015: the General Status of Species in Canada (in preparation). National General Status Working Group.
- Cane, J. H. 2003. Exotic nonsocial bees (Hymenoptera: Apiformes) in North America: ecological implications. Pp. 113–126 in K. Strickler and Cane, J.H. (eds.). *For Nonnative Crops, Whence Pollinators of the Future?* Thomas Say Publications in Entomology: Proceedings of the Entomological Society of America, Lanham, MD. 204 pp.
- Chivian, E. and Bernstein, A (eds.). 2008. *Sustaining life. How human health depends on biodiversity.* Oxford University Press, New York, NY. 542 pp.
- Colla, S. R., Willis, E. and Packer, L. 2009. Can green roofs provide habitat for urban bees (Hymenoptera: Apidae)? *Cities and the Environment*. 2(1): article 4, 12 pp. <http://escholarship.bc.edu/cate/vol2/iss1/4>.
- Cooper, K. W. 1984. Discovery of first resident population of the European bee, *Megachile apicalis*, in the United States (Hymenoptera: Megachilidae). *Entomological News* 95: 225–226.
- Crane, E. 1999. *The world history of beekeeping and honey hunting.* Duckworth, London, UK. 682 pp.
- Danforth, B. N. and Ji, S. 2001. Australian *Lasioglossum* + *Homalictus* form a monophyletic group: resolving the “Australian enigma”. *Systematic Biology* 50: 268–283.
- Droege, S. 2008. North American (North of Mexico) introduced and alien bee species, available online at: http://pollinators.nbj.gov/documents/NAm_Introduced_and_Alien_Bee_Species_Jul2008.pdf [last accessed: 27 July 2011].
- Dumesh, S. and Sheffield, C. S. (in press). Bees of the genus *Dufourea* Lepeletier (Hymenoptera: Halictidae: Rophitinae) in Canada and Alaska. *Canadian Journal of Arthropod Identification*.
- Ebmer, A. W. 1976. *Lasioglossum discum* (Smith): a West Palaearctic rather than a Nearctic species (Hymenoptera: Halictidae). *Journal of the Kansas Entomological Society* 49: 141.
- Eickwort, G. C. 1970. *Hoplitis anthocopoides*, a European mason bee established in New York state (Hymenoptera: Megachilidae). *Psyche* 77: 190–201.
- Eickwort, G. C. 1975. Nest-building behavior of the mason bee *Hoplitis anthocopoides* (Hymenoptera: Megachilidae). *Zeitschrift für Tierpsychologie* 37: 237–254.
- Eickwort, G. C. 1980. Two European species of *Chelostoma* established in New York State (Hymenoptera: Megachilidae). *Psyche* 87: 315–324.
- Free, J. B. 1993. *Insect pollination of crops*, Second Edition. Academic Press, San Diego, CA. 684 pp.
- Gibbs, J. 2010. Revision of the metallic species of *Lasioglossum* (*Dialictus*) in Canada (Hymenoptera, Halictidae, Halictini). *Zootaxa* 2591: 1–382.
- Gibbs, J. and Sheffield, C. S. 2009. Rapid range expansion of the Wool-Carder Bee, *Anthidium manicatum* (Linnaeus) (Hymenoptera: Megachilidae), in North America. *Journal of the Kansas Entomological Society* 82: 21–29.

- Giles, V. and Ascher, J. S. 2006. A survey of the bees of the Black Rock Forest Preserve, New York (Hymenoptera: Apoidea). *Journal of Hymenoptera Research* 15: 208–231.
- Grixti, J. C. and Packer, L. 2006. Changes in the bee fauna (Hymenoptera: Apoidea) of an old field site in southern Ontario, revisited after 34 years. *The Canadian Entomologist* 138: 147–164.
- Gosek, J., Ruszkowski, A. and Kaczmarska, K. 1995. Food plants and an economic importance of *Hylaeus* species of subgenera *Spatulariella* Popov, *Abrupta* Popov and *Koptogaster* Alfken (Hymenoptera, Colletidae). *Pszczelnicze Zeszyty Naukowe* 39: 265–272.
- Hinojosa-Díaz, I. A., Yáñez-Ordóñez, O., Chen, G., Peterson, A. T. and Engel, M. S. 2005. The North American invasion of the giant resin bee (Hymenoptera: Megachilidae). *Journal of Hymenoptera Research* 14: 69–77.
- Hoebeke, E. R. and Wheeler, Jr., A. G. 1999. *Anthidium oblongatum* (Illiger): an Old World bee (Hymenoptera: Megachilidae) new to North America, and new North American records for another adventive species, *A. manicatum* (L.). University of Kansas Natural History Museum Special Publication 24: 21–24.
- Horn, T. 2005. Bees in America. How the honey bee shaped a nation. University Press of Kentucky, Lexington, KY. 333 pp.
- Jaycox, E. R. 1967. An adventive *Anthidium* in New York State (Hymenoptera: Megachilidae). *Journal of the Kansas Entomological Society* 40: 124–126.
- Magnum, W. A. and Brooks, R. W. 1997. First records of *Megachile* (*Callomegachile*) *sculpturalis* Smith (Hymenoptera: Megachilidae) in the continental United States. *Journal of the Kansas Entomological Society* 70: 146–148.
- Magnum, W. A. and Sumner, S. 2003. A survey of the North American range of *Megachile* (*Callomegachile*) *sculpturalis*, an adventive species in North America. *Journal of the Kansas Entomological Society* 76: 658–662.
- Maier, C. T. 2009. New distributional records of three alien species of Megachilidae (Hymenoptera) from Connecticut and nearby states. *Proceedings of the Entomological Society of Washington* 111: 775–784.
- Majka, C. G. and LeSage, L. 2006. Introduced leaf beetles of the Maritime Provinces, 1. *Sphaeroderma testaceum* (Fabricius) (Coleoptera: Chrysomelidae). *Proceedings of the Entomological Society of Washington* 108: 243–247.
- Malloch, J. R. 1918. Occurrence of a European solitary bee (*Andrena wilkella* Kirby) in the eastern United States. *Proceedings of the Biological Society of Washington* 31: 61–64.
- Matteson, K. C., Ascher, J. S. and Langellotto, G. A. 2008. Bee richness and abundance in New York City urban gardens. *Annals of the Entomological Society of America* 101: 140–150.
- McGinley, R. J. 1986. Studies of Halictinae (Apoidea: Halictidae), I: Revision of New World *Lasioglossum* Curtis. *Smithsonian Contributions to Zoology* 429: 1–294.
- Miller, S. R., Gaebel, R., Mitchell, R. J. and Arduser, M. 2002. Occurrence of two species of old world bees, *Anthidium manicatum* and *A. oblongatum* (Apoidea: Megachilidae), in northern Ohio and southern Michigan. *The Great Lakes Entomologist* 35: 65–70.

- Mitchell, T. B. 1960. Bees of the eastern United States. Volume I. North Carolina Agricultural Experimental Station Technical Bulletin 141: 1–538.
- Packer, L. 1998. A phylogenetic analysis of western European species of the *Lasioglossum leucozonium* species-group (Hymenoptera: Halictidae): sociobiological and taxonomic implications. Canadian Journal of Zoology 76: 1611–1621.
- Paiero, S. M. and Buck, M. 2004 [2003]. First Canadian records of the giant resin bee, *Megachile sculpturalis* Smith, and other introduced and native Megachilidae and Andrenidae (Apoidea) from Ontario. Journal of the Entomological Society of Ontario 134: 141–143.
- Pitts-Singer, T. L. and Cane, J. H. 2011. The Alfalfa Leafcutting Bee, *Megachile rotundata*: the world's most intensively managed solitary bee. Annual Review of Entomology 56: 221–237.
- Provancher, L. 1882. Faune Canadienne. Les insectes hyménoptères. Le Naturaliste Canadien 13: 225–242.
- Rehan, S. M. and Sheffield, C. S. 2011. Morphological and molecular delineation of a new species in the *Ceratina dupla* species-group (Hymenoptera: Apidae) of eastern North America. Zootaxa 2873: 35–50.
- Richards, M. H., Rutgers-Kelly, A., Gibbs, J., Vickruck, J. L., Rehan, S. M. and Sheffield, C. S. 2011. Bee diversity in naturalizing patches of Carolinian grasslands in southern Ontario, Canada. The Canadian Entomologist 143: 279–299.
- Romankova, T. G. 2003. Ontario nest-building bees of the tribe Anthidiini (Hymenoptera, Megachilidae). Journal of the Entomological Society of Ontario 134: 85–89.
- Romankova, T. G. 2007. Bees of the genus *Hylaeus* of Ontario (Hymenoptera: Apoidea: Colletidae). Journal of the Entomological Society of Ontario 138: 137–154.
- Rust, R. W. 1974. The systematic and biology of the genus *Osmia*, subgenera *Osmia*, *Chalcosmia*, and *Cephalosmia* (Hymenoptera: Megachilidae). Wasmann Journal of Biology 32: 1–93.
- Sheffield, C. S. 2008. Summer bees for spring crops? Potential problems with *Megachile rotundata* (Fab.) (Hymenoptera: Megachilidae) as a pollinator of lowbush blueberry (Ericaceae). Journal of the Kansas Entomological Society 81: 276–287.
- Sheffield, C. S., Kevan, P. G., Smith, R. F., Rigby, S. M. and Rogers, R. E. L. 2003. Bee species of Nova Scotia, Canada, with new records and notes on bionomics and floral relations (Hymenoptera: Apoidea). Journal of the Kansas Entomological Society 76: 357–384.
- Sheffield, C. S., Kevan, P. G., Westby, S. M. and Smith, R. F. 2008. Diversity of cavity-nesting bees (Hymenoptera: Apoidea) within apple orchards and wild habitats in the Annapolis Valley, Nova Scotia, Canada. The Canadian Entomologist 140: 235–249.
- Sheffield, C. S., Richards, M. and Griswold, T. 2010. Discovery of the Old World bee, *Megachile (Pseudomegachile) ericetorum* (Hymenoptera: Megachilidae), in Ontario, Canada. Journal of the Entomological Society of Ontario 141: 85–92.
- Sheffield, C. S., Ratti, C., Packer, L. and Griswold, T. (in press) Leafcutter and mason bees of the genus *Megachile* Latreille (Hymenoptera: Megachilidae) in Canada and Alaska. Canadian Journal of Arthropod Identification.
- Smith, I. P. 1991. *Anthidium manicatum* (Hymenoptera: Megachilidae), an interesting new

- Canadian record. Proceedings of the Entomological Society of Ontario 122:105–108.
- Snelling, R. R. 1970. Studies on North American bees of the genus *Hylaeus*. 5. The subgenera *Hylaeus*, s. str. and *Paraprosopis* (Hymenoptera: Colletidae). Los Angeles County Museum, Contributions in Science 180: 1–59.
- Snelling, R. R. 1983. Studies on North American bees of the genus *Hylaeus* 6. An adventive Palearctic species in southern California (Hymenoptera: Colletidae). Bulletin of the Southern California Academy of Sciences 82: 12–16.
- Strange, J. P., Koch, J. B., Gonzalez, V. H., Nemelka, L. and Griswold, T. 2011. Global invasion by *Anthidium manicatum* (Linnaeus) (Hymenoptera: Megachilidae): assessing potential distribution in North America and beyond. Biological Invasions 13: 2115–2133.
- Tonietto, R. K. and Ascher, J. S. 2008. Occurrence of the old world bee species *Hylaeus hyalinatus*, *Anthidium manicatum*, *A. oblongatum*, and *Megachile sculpturalis*, and the native species *Coelioxys banksi*, *Lasioglossum michiganense*, and *L. zohops* in Illinois (Hymenoptera: Apoidea: Colletidae, Halictidae, Megachilidae). The Great Lakes Entomologist 41: 200–203.
- Toro, H., Frederick, Y. and Henry, A. 1989. Hylaeinae (Hymenoptera: Colletidae), a new sub-family of bees for the Chilean fauna. Acta Entomologica Chilena 15: 201–204.
- Westrich, P. 1990. Die Wildbienen Baden-Württembergs, Teil 2, Eugen Ulmer, Stuttgart. pp. 437–972.
- Wilson, E. O. 1999. The Diversity of Life. New Edition. W.W. Norton and Company, New York, NY. 424 pp.