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Urban Populations of a Declining Bumble Bee Species, *Bombus pensylvanicus* (De Geer) (Hymenoptera: Apidae), in the District of Columbia, USA

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Abstract: We document nesting and foraging activities of the American Bumble Bee, *Bombus pensylvanicus* (De Geer) (Hymenoptera: Apidae), in urbanized areas of the District of Columbia, USA, in 2013 and 2014. Two areas were located within the District that supported populations of *B. pensylvanicus*: the United States National Arboretum in the northeastern portion of the District, and the Shaw neighborhood located north of the central urban core. Adults of *B. pensylvanicus* were observed foraging on flowers of 18 plant species in 8 plant families, primarily non-native ornamental plants such as lavender, *Lavandula* L. spp. (Lamiaceae); larkspur, *Delphinium* L. spp. (Ranunculaceae); and orange eye butterflybush, *Buddleja davidii* Franchet (Scrophulariaceae). Urban nests of *B. pensylvanicus* were observed in ornamental grass clumps, a grassy meadow, and an overgrown vacant lot. These observations suggest that ornamental plantings in urban areas have the potential to provide habitat for rare and declining bumble bee species such as *B. pensylvanicus*.

Keywords: *Bombus*, bumble bee, conservation, urban, nesting, foraging, non-native plant

Significant declines have been observed in recent decades in populations of several North American species of the genus *Bombus* Latreille (Hymenoptera: Apidae), including the formerly widespread eastern North American species *Bombus pensylvanicus* (De Geer) (American Bumble Bee) (Shepherd et al. 2005, Brown 2011, Cameron et al. 2011) (Figure 1). According to Cameron et al. (2011), the geographic area occupied by populations of *B. pensylvanicus* has declined nearly 23 percent in recent decades, with the declines most prominent in the northern and eastern portions of the species' range (see Figure 1D in Cameron et al. 2011). The species has also apparently declined in overall abundance in those parts of its range where it can still be found (Droege, in litt.).

Bombus pensylvanicus has traditionally been considered a grassland species, nesting on the ground surface or in grass clumps (Colla et al. 2011, Williams et al. 2014).). Rau (1924) states that this species appears to nest preferentially in "situations where the grass grows tall and falls over, year after year, thus making a thick, soft mat." Although Droege (2007) included *B. pensylvanicus* on a list of bee species occurring within the District of Columbia region, it has not generally been associated with urban areas.

Figure 1. American Bumble Bee, *Bombus pensylvanicus* (De Geer). Female foraging on orange eye butterflybush, *Buddleja davidii* Franchet. 1225 O Street NW, Shaw Neighborhood, Washington, District of Columbia, 4 August 2014.

While conducting observational studies of a large nesting aggregation of the Eastern Carpenter Bee, *Xylocopa virginica* (Linnaeus) (Hymenoptera: Apidae), at the United States National Arboretum in Washington, District of Columbia, USA, we also observed adults of *B. pensylvanicus* and several other *Bombus* species visiting flowers in the formal planted gardens. Given the considerable conservation interest associated with these species, we expanded our initial field study to include observations of floral visitation by *B. pensylvanicus* and other *Bombus* species. These observations extended throughout the 2013 and 2014 field seasons (March-October each year).

During the summer of 2014, the senior author observed adults of *B. pensylvanicus* on flowers in the Shaw neighborhood of Washington, DC. This is a densely urbanized area with adjoining row houses and landscaped gardens and parks. Given the unusual nature of this observation, we initiated a systematic search of the entire neighborhood during the month of August 2014, for additional individuals of *B. pensylvanicus*.

The observations reported here demonstrate that *B. pensylvanicus* will nest in urban areas, that these nests can produce new reproductive individuals in the late summer, and that individuals of this species will forage on a range of native and non-native plant species. It is hoped that this initial study will help stimulate further investigations of the

activity patterns of rare or declining native bees such as *B. pensylvanicus* in urban areas, not just in North America, but throughout the world.

METHODS

We initiated observational studies of a nesting aggregation of *Xylocopa virginica* at the National Arboretum in the spring of 2013. During the course of those observations, we also observed adults of *B. pensylvanicus* and other *Bombus* species (*B. auricomus* [Robertson] (Black-and-Gold Bumble Bee), *B. bimaculatus* Cresson (Two-spotted Bumble Bee), *B. griseocollis* [DeGeer] (Brown-belted Bumble Bee), and *B. impatiens* Cresson) (Common Eastern Bumble Bee) visiting flowers in the same areas where adult carpenter bees were active. Because of the conservation interest in certain species of *Bombus* (Brown 2011, Cameron et al. 2011), we added observations of *Bombus* species to our field observation protocols.

A set of standard linear observation walking transects were established along the major trails and footpaths in each of three areas at the National Arboretum: the National Bonsai and Penjing Museum, the National Herb Garden, and the Fern Valley Native Plant Collection. Transects were designed to facilitate examination of all inflorescences of flowering plant species within each garden without duplication. Each transect was walked by both authors at least once weekly and the activity patterns and floral associates of *Bombus* and *Xylocopa* species were recorded. Adults of *Bombus* species were identified in the field using published identification guides (principally Colla et al. 2011, but also Williams et al. 2014) and voucher specimens were collected for comparison with authoritatively identified specimens in the collections of the National Museum of Natural History, Smithsonian Institution, Washington, DC.

A chance observation on 31 July 2014 of a single worker of *B. pensylvanicus* in a private garden located on O Street NW in the Shaw neighborhood of the District of Columbia led us to initiate systematic surveys for additional adults of this species in the same neighborhood. Each street and alley within a 0.5-km (0.3-mi) radius of the original observation site was walked at least twice during August 2014, and all flowers in private yards, public rights-of-way, and parks were examined for individuals of this species.

Adults of *B. pensylvanicus* in the District of Columbia are similar in coloration to adults of *B. auricomus*, a species which co-occurs with *B. pensylvanicus* at the National Arboretum. Given the strong similarity between adults of these two species, we accordingly took steps to make certain that our field identifications of these two species were accurate. The coloration of the pubescence on the vertex of the head is commonly given as the character for separating these two species (vertex with yellow pubescence in *B. auricomus*; entirely black in *B. pensylvanicus* [Colla et al. 2011, Williams et al. 2014]). In practice, this character is not always readily visible in the field, especially when the bees are taking nectar from flowers or are covered in pollen. In cases when the coloration of the head pubescence was not readily apparent, we collected bees in glass vials for closer observation and examination of the pubescence. Voucher specimens were also collected for study under a compound dissecting scope to confirm species identifications.

Urban nest sites of *B. pensylvanicus* were identified by a three-step process: we first plotted the direction of flight of returning foragers on a base map derived from the Google Maps imagery (https://maps.google.com), identified those areas where flight vectors from multiple foraging bees converged, and then conducted careful visual inspections of these areas in order to detect bees returning to and departing from the actual nest sites.

RESULTS

We recorded the following observations of *B. pensylvanicus* in the District of Columbia during the 2013 and 2014 field seasons. A gazetteer with latitude and longitude coordinates for all sites is provided in Table 1. Botanical names follow those on labels provided by the National Arboretum, including varietal names for cultivars. For plant species with variably colored flowers, we record the color of the flowers that were visited by adults of *B. pensylvanicus*. No adults of *B. pensylvanicus* were observed at the National Bonsai and Penjing Museum, which was the site of a large nesting aggregation of *Xylocopa virginica*.

Table 1. Gazetteer of sites where adults of *Bombus pensylvanicus* were observed in 2013 and 2014 within the District of Columbia.

Site	Latitude	Longitude
National Arboretum – Fern Valley Native Plant Collection	38.9089°	-76.9658°
National Arboretum – National Herb Garden	38.9116°	-76.9693°
1328 9th Street NW	38.9081°	-77.0241°
900 O Street NW	38.9086°	-77.0242°
935 O Street NW	38.9086°	-77.0254°
1225 O Street NW	38.9014°	-77.0291°
1113 R Street NW	38.9127°	-77.0276°
949 T Street NW	38.9157°	-77.0258°
1800 Vermont Avenue NW	38.9148°	-77.0268°
1838 Vermont Avenue NW	38.9153°	-77.0265°
Stead Park (1625 P Street NW)	38.9097°	-77.0374°

USA: District of Columbia: United States National Arboretum

Fern Valley Native Plant Collection: 1.IX.2013, 2 workers on flowers of *Chelone obliqua* L. (Scrophulariaceae); 18.V.2014, 1 queen on flowers of *Baptisia sphaerocarpa* Nuttall X *B. alba* (L.) Ventenat 'Carolina moonlight' (Fabaceae); 26.V.2014, 1 queen on flowers of *Baptisia australis* (L.) Robert Brown; 24.VIII.2014, 1 queen on flowers of *Silphium integrifolium* Michaux (Asteraceae), 1 worker on flowers of *Chelone glabra* L. (Scrophulariaceae); 14.IX.2014, 4 workers on flowers of *Chelone obliqua*; 28.IX.2014, 1 queen and 1 worker on flowers of *Chelone obliqua*.

National Herb Garden: 2.VI.2013, 2 workers on flowers of *Delphinium* L. sp. (Ranunculaceae); 10.VI.2013, 8 workers on flowers of *Delphinium* sp.; 30.VI.2013, 1 worker on flowers of *Lavandula angustifolia* Miller (Lamiaceae) 'rosea', 1 worker on flowers of *Lavandula* x*intermedia* 'abrialii', 1 worker on flowers of *Lavandula* x*intermedia* 'silver', 1 worker on flowers of *Cynara cardunculus* L. (Asteraceae), 1 worker on flowers of *Delphinium* sp.; 14.VII.2013, 1 worker on flowers of *Cynara cardunculus*; 28.VII.2013, 1 worker on flowers of *Cynara cardunculus*; 21.IV.2014, 1 queen on flowers of *Myrrhis odorata* (L.) Scopoli (Apiaceae); 22.VI.2014, 1 worker on flowers of *Lavandula* x*intermedia* 'Provence,' 1 worker on flowers of *Lavandula* x*intermedia* 'Hidcote giant,' 1 worker on flowers of *Lavandula* x*intermedia* 'super,' 1 worker on flowers of *Lavandula angustifolia* 'Blue Ridge,' 1 worker on flowers of *Lavandula* x*intermedia* 'abrialii,' 1 worker on flowers of *Lavandula* x*intermedia* 'Sussex,' 3 queens and 13 workers on flowers of *Delphinium* sp., 1 worker on flowers of *Cephalanthus occidentalis* L. (Rubiaceae); 29.VI.2014, 2 workers on flowers of *Lavandula* x*intermedia* 'Hidcote giant,' 1 worker on flowers of *Lavandula* x*intermedia* 'abrialii,' 2 workers on flowers of *Lavandula* x*intermedia* 'silver,' 6 workers on flowers of *Delphinium* sp., 1 worker on flowers of *Geranium* L. sp. (Geraniaceae); 13.VII.2014, 1 queen on flowers of *Delphinium* sp., 1 queen on flowers of *Hibiscus* L. sp. (Malvaceae), 1 worker on flowers of *Alcea* L. sp. (Malvaceae); 27.VII.2014, 3 workers on flowers of *Cynara cardunculus*; 11.VIII.2014, 2 workers on flowers of *Salvia* L. sp. (Lamiaceae); 31.VIII.2014, 1 worker on flowers of *Coreopsis tinctoria* (Nuttall) (Asteraceae), 1 queen on flowers of *Lablab purpureus* (L.) Sweet (Fabaceae); 14.IX.2014, 1 worker on flowers of *Salvia microphylla* Kunth (Lamiaceae) 'San Carlos festival.'

USA: District of Columbia: Shaw Neighborhood

1328 9th Street NW: 6.VIII.2014, 3 workers on flowers of *Buddleja davidii* Franchet (Scrophulariaceae) (pink); 11.VIII.2014, 1 worker on flowers of *Buddleja davidii* (pink).

900 O Street NW: 29.VIII.2014, 1 male, dead on ground.

935 O Street NW: 31.VII.2014, 1 worker on flowers of *Monarda* L. sp. (Lamiaceae) and *Hibiscus* sp.

1225 O Street NW: 4.VIII.2014, 1 worker on flowers of *Buddleja davidii* (purple); 13.VIII.2014, 1 male on flowers of *Buddleja davidii* (purple).

1113 R Street NW: 7.VIII.2014, 1 worker on flowers of *Buddleja davidii* (purple); 11.VIII.2014, 1 worker on flowers of *Buddleja davidii* (purple); 13.VIII.2014, 1 male on flowers of *Buddleja davidii* (purple).

949 T Street NW: 11.VIII.2014, 1 queen on flowers of *Passiflora* L. sp. (Passifloraceae).

1800 Vermont Avenue NW: 6.VIII.2014, 1 worker on flowers of *Buddleja davidii* (white); 7.VIII.2014; 1 worker on flowers of *Buddleja davidii* (white); 11.VIII.2014, 2 queens on flowers of *Buddleja davidii* (white); 15.VIII.2014, 2 queens and 1 worker on flowers of *Buddleja davidii* (white); 18.VIII.2014, 2 queens on flowers of *Buddleja davidii* (white); 19.VIII.2014, 1 queen on flowers of *Buddleja davidii* (white); 22 VIII 2014, 2 queens on flowers of *Buddleja davidii* (white).

1838 Vermont Avenue NW: 11.VIII.2014, 1 worker on flowers of *Buddleja davidii* (purple); 18.VIII.2014, 1 queen on flowers of *Buddleja davidii* (white).

Stead Park (1625 P Street NW): 19.VIII.2014: 1 worker on flowers of *Buddleja davidii* (purple); 20.VIII.2014, 1 worker on flowers of *Buddleja davidii* (purple).

NESTING SITES

Three nesting sites for *B. pensylvanicus* were identified during the course of the field observations. One nest was located in a large, grassy meadow at the National Arboretum located due south of the National Herb Garden and due west of the Fern Valley Native Plant Garden. This area may have contained additional nests, judging by the large number of foraging workers that were observed in both years. A second nest was located in dense grassy and herbaceous vegetation in an overgrown vacant lot at 1328 9th Street NW. Finally, a third nest was located in dense clumps of ornamental grasses in a small public park directly across the street from the house at 1838 Vermont Avenue NW. All three nests were hidden in dense grassy and/or herbaceous vegetation; within large grass clumps for the nests at the National Arboretum and Vermont Avenue sites, and in a dense tangle of grass clumps and weedy herbaceous vegetation for the nest at the 9th Street NW site. The location and appearance of these sites generally corresponds to the description of the preferred nesting habitat for this species provided by Rau (1924): "situations where the grass grows tall and falls over, year after year, thus making a thick, soft mat."

DISCUSSION

Our observations document the presence of *Bombus pensylvanicus* within the Washington, DC, urban environment, as well as the use of anthropogenic habitat features such as vacant lots, grassy meadows, and ornamental plantings for foraging and nesting activities of this species. Particularly interesting from a conservation standpoint are the use of non-native ornamental grass species for nesting, and the extensive foraging activities that we observed on non-native flowering plants, particularly *Buddleja davidii*. Although this plant species is frequently used in ornamental garden plantings in the urban areas we studied, it also has undesirable invasive properties, to the extent that it has been included in the book *Plant Invaders of Mid-Atlantic Natural Areas* (Swearingen et al. 2010). At the same time, flowers of *Buddleja davidii* clearly offer important late-summer foraging opportunities to *B. pensylvanicus* as well as other native bee species. *Buddleja davidii* was one of the few plant species offering floral rewards in the Shaw neighborhood at the time of our surveys in August 2014. This plant species provides important resources for pollinator species that are active later in the summer such as *B.*

pensylvanicus. The role of non-native plant species in supporting populations of rare or declining pollinator species such as *B. pensylvanicus* clearly merits further investigation.

At the National Arboretum, adults of *B. pensylvanicus* were observed foraging at the same time as adults of four other species of the genus *Bombus*: *B. auricomus*, *B. bimaculatus*, *B. griseocollis* and *B. impatiens*. Of these five species, *B. impatiens* was clearly the most abundant. In 2014, for example, we recorded 405 observations of floral visitation by *B. impatiens* queens, workers, or males at the National Arboretum (compared with the 58 observations of floral visitation by individual *B. pensylvanicus* at the National Arboretum in 2014 reported above). *Bombus impatiens* is apparently even more adapted to urban life than *B. pensylvanicus*; adults of this species are ubiquitous throughout the Washington, DC metropolitan area and are commonly found on flowers of ornamental plantings, including both native and non-native plant species. We have observed nests of *B. impatiens* in ornamental plantings on the National Mall, in urban garden plots, in vacant lots, in debris piles, and in abandoned building foundations.

Our observations suggest that *B. pensylvanicus* may be capable of sustaining populations over multiple years and multiple generations at sites in urban areas. We observed nests of this species in multiple successive years at the National Arboretum, and also noted the presence of adult reproductives in August at both the National Arboretum and Shaw neighborhood sites. Further research is needed to determine whether these urban populations of *B. pensylvanicus* are indeed self-sustaining, or whether colonization of suitable urban sites by female reproductives from outside the urban area may also be occurring.

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