

# Colony distribution and prey diversity of *Cerceris fumipennis* (Hymenoptera, Crabronidae) in British Columbia

Troy Kimoto<sup>1</sup>, Josie Roberts<sup>2</sup>, Richard L. Westcott<sup>3</sup>, Eduard Jendek<sup>4</sup>,  
Matthias Buck<sup>5</sup>, David Holden<sup>1</sup>, Philip D. Careless<sup>6</sup>

**1** Canadian Food Inspection Agency, 4321 Still Creek Drive, Burnaby, British Columbia, Canada, V5C 6S7  
**2** Canadian Food Inspection Agency, 506 West Burnside Road, Victoria, British Columbia, Canada, V8Z 1M5  
**3** Oregon Department of Agriculture, 635 Capitol NE, Salem, Oregon, United States of America, 97301-2532  
**4** Canadian Food Inspection Agency, 960 Carling Avenue, Ottawa, Ontario, Canada, K1A 0Y9 **5** Royal Alberta Museum, 12845-102nd Avenue, Edmonton, Alberta, Canada, T5N 0M6 **6** Toronto, Ontario, Canada, M4R 1H9

Corresponding author: Troy Kimoto ([troy.kimoto@inspection.gc.ca](mailto:troy.kimoto@inspection.gc.ca))

Academic editor: J. Neff | Received 11 July 2015 | Accepted 17 September 2015 | Published 30 November 2015

<http://zoobank.org/25A79550-C555-4BC8-807D-C66E0ADC3B35>

**Citation:** Kimoto T, Roberts J, Westcott RL, Jendek E, Buck M, Holden D, Careless PD (2015) Colony distribution and prey diversity of *Cerceris fumipennis* (Hymenoptera, Crabronidae) in British Columbia. Journal of Hymenoptera Research 46: 45–59. doi: 10.3897/JHR.46.5644

## Abstract

*Cerceris fumipennis* Say, 1837 (Hymenoptera: Crabronidae) is a wasp that provisions its subterranean nests with jewel beetles (Coleoptera: Buprestidae). At 3 newly discovered colonies in British Columbia (BC), *C. fumipennis* prey were collected by excavating the subterranean nests, using sweep nets to capture paralyzed prey in the grasp of a female returning to her nest, or collecting prey discarded at the nest entrance. In total, 9 species were collected: *Acmaeodera idahoensis* Barr, *Agrilus crataegi* Frost, *Agrilus granulatus populi* Fisher, *Anthaxia (Haplantaxia) caseyi caseyi* Obenberger, *Chrysobothris laricis* Van Dyke, *Chrysobothris leechi* Barr, *Phaenops drummondi* (Kirby), *Phaenops gentilis* (LeConte) and *Phaenops intrusa* (Horn). *Anthaxia caseyi caseyi* was the smallest beetle (4.2 mm) while *C. leechi* was the largest (12.0 mm). The average size of all buprestid prey taken by females from all 3 colonies was 8.8 mm. These represent the first prey records for *C. fumipennis* in BC and with the exception of *P. drummondi* are new prey records for this wasp. A single *Harpalus affinis* (Schrank) (Coleoptera: Carabidae) was discovered within a brood cell containing *Acmaeodera* spp. elytra, but it is unclear if this beetle was placed in the cell by a female wasp.

## Keywords

*Cerceris fumipennis*, Hymenoptera, Crabronidae, biosurveillance, pest detection

## Introduction

*Cerceris fumipennis* Say, 1837 (Hymenoptera: Crabronidae) is a ground-nesting wasp in which females provision their nests with paralysed buprestid beetles in jelly bean shaped subterranean cells (Scullen 1965; Hook and Evans 1991; Marshall et al. 2005). In Canada, colonies have been discovered in western Québec and throughout southern Ontario (Buck 2004; Marshall et al. 2005; Careless et al. 2009; Careless 2010). In 2012 and 2013, a total of 1 male and 4 females were captured by sweep net at a colony in Merritt, British Columbia (BC) (Kimoto and Buck 2015). This represents the first time *C. fumipennis* has been recorded from BC since 1935 (2 females collected by R.H. Beamer on 3 August 1935; University of Kansas Natural History Museum, Lawrence, Kansas, US) and also represents the first recorded colony.

Female *Cerceris fumipennis* are adept at capturing a wide variety of buprestid beetles, and have been the source for various new provincial, state and national records (Marshall et al. 2005). Therefore, it has been used in eastern North America by the Canadian Food Inspection Agency (CFIA) and other departments as a biosurveillance tool to detect the non-indigenous emerald ash borer, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae) (Marshall et al. 2006; Careless et al. 2009; Nalepa et al. 2012; Careless et al. 2014). In the eastern US, citizen-scientist programs have been established whereby colonies are “adopted” and monitored by the public. In 2012, an adopted *C. fumipennis* colony was responsible for the first state record of emerald ash borer in Connecticut (Rutledge et al. 2013). It is the intention of the senior author to establish citizen-scientist programs in BC to detect non-indigenous buprestid beetles, but additional colonies need to be discovered before this can occur.

In 2013 and 2014, additional sites from the Greater Vancouver Region, the Fraser Canyon, and the Okanagan Valley were examined for the presence of *Cerceris fumipennis* colonies. This paper outlines the variety of sites examined, the location of two new colonies and first prey records for *C. fumipennis* in BC.

## Methods and materials

### Searching for *Cerceris* colonies

In 2013, 13 sites in Ashcroft, Spence’s Bridge, Cache Creek, Skihist, Boston Bar, Vernon, and West Kelowna were examined. In 2014, 85 sites in Kamloops, West Kelowna, Coldstream, Vernon, Osoyoos, Oliver, Okanagan Falls, Penticton, Summerland, Chilliwack, Merritt, Logan Lake, Lytton, Hope, Coquihalla Highway, Kane Valley Road, Cloverdale, Lillooet, Duffy Lake Road, Richmond, Ashcroft, Cache Creek, Clinton, Hat Creek, and Pavilion were examined.

Google Maps (2014) was used to find baseball fields and other areas with bare patches of soil exposed to full sun. The ground at each site was examined for the presence of circular holes and tumuli. Where possible, the central location of the Merritt colony was used to reinforce the search image of nest entrance shape and size. When entrance holes approximately 5–7 mm in diameter were discovered, clear plastic cups were placed over these holes and returning wasps were captured in sweep nets. Specimens were placed in glass vials with 75% ethanol and submitted to Matthias Buck for identification and deposited at the Royal Alberta Museum in Edmonton.

### **Collecting *Cerceris fumipennis* prey at nest entrances**

Beetles were collected at *Cerceris fumipennis* colonies during 4 days in July and 2 days in August 2014. Clear plastic cups were placed over entrance holes and a sweep net was used to collect female wasps returning with prey. The nest entrances and completely enclosed tumuli were also examined for dropped prey.

### ***Cerceris fumipennis* nest excavation**

On 25 July 2014, a single nest at the north end of St. Georges Road, Lytton was excavated. Using a trowel, soil around the nest entrance was removed and placed onto a cleared area. The soil was carefully broken into smaller pieces. Upon discovering a cell containing buprestid beetles or wasp cocoons, a tape measure was used to determine the depth below the surface. The contents of each cell was described and recorded. On 7 August 2014, a single nest that was at least 2 feet away from any other visible *Cerceris fumipennis* nest entrances was excavated at the Central Park colony in Merritt. Methodology followed that used in Lytton. On August 11, an additional 4 nests were excavated in Merritt, but the depth at which buprestid specimens were discovered was not recorded.

All beetles collected at the nest entrances and during excavation were placed in 100% USP/FCC propylene glycol and sent to the CFIA entomology laboratory in Victoria where they were identified and their length measured, to the nearest one tenth mm, using a Leica microscope (DFC495) along with Leica Applications Suite 4.1. These specimens were pinned, labelled and then sent to Eduard Jendek and Richard Westcott for confirmation of species determination.

### **Soil analysis**

One soil sample immediately adjacent to (Lillooet) or within (Merritt, Lytton) a known *Cerceris fumipennis* nest was collected from each of the 3 colonies. Approximately 50 g of air-dried soil was submitted to the British Columbia Ministry of Environment to assess soil texture (sand, silt and clay composition) and organic content (2 mm sieve pass, loss on ignition).

## Results

### New colonies

Thirteen sites were examined in 2013 and 85 sites were examined from 30 June to 29 July 2014 (Table 1). Thirty percent of all sites were baseball fields (red shale), 22% were dirt roads (compact soil), 8% were baseball fields (compact soil) and 6% were parking lots (compact soil). On 11 July 2014, one female *Cerceris fumipennis* was captured in a sweep net in a dirt parking lot at the north end of St. Georges Road in Lytton. This colony occurs a few hundred metres north of the Stein Valley Nlakapamux School in compact sand adjacent to a baseball field (Fig. 1). A few ant nests but no *C. fumipennis* nests were observed in this baseball diamond. Two females were also captured on 17 July 2014 in a sweep net at a dirt parking lot, comprised of compact sand, adjacent to P'egg'ig'lha Community Centre in Lillooet (Fig. 2). Table 2 and Figure 3 provide additional information and show the relative location of each colony. As per the previous description of *C. fumipennis* specimens from BC (Kimoto and Buck 2015), the average fore wing length of the Lytton and Lillooet specimens is approximately 10.5 mm which

**Table 1.** List of sites examined for *Cerceris* colonies in BC, excluding Central Park, Merritt.

Year	Site Type	Substrate	Number of sites examined	<i>C. fumipennis</i> colonies
2013	Dirt roads, parking lots	Gravel	1	0
	Baseball fields	Red shale	4	0
	Baseball fields	Compact sand	2	0
	Baseball fields	Loose sand	1	0
	Running ovals	Gravel	2	0
	School yard	Gravel	2	0
	Field	Compact sand	1	0
2014	Dirt roads, parking lots	Gravel	5	0
	Dirt road	Compact sand	22	0
	Parking lot	Compact sand	6	2
	Baseball fields	Red shale	25	0
	Baseball fields	Compact sand	6	0
	Baseball fields	Loose sand	3	0
	Running ovals	Gravel	3	0
	Running ovals	Compact sand	1	0
	Equestrian centre	Loose sand or gravel	3	0
	Airstrip	Gravel or compact sand	2	0
	Campground	Gravel	4	0
	Picnic site	Gravel	1	0
	Beach (lake)	Loose sand	1	0
	Cemetery	Gravel, compact sand	1	0
	Natural area (desert)	Covered in vegetation	1	0
Misc. open area	Loose sand	1	0	



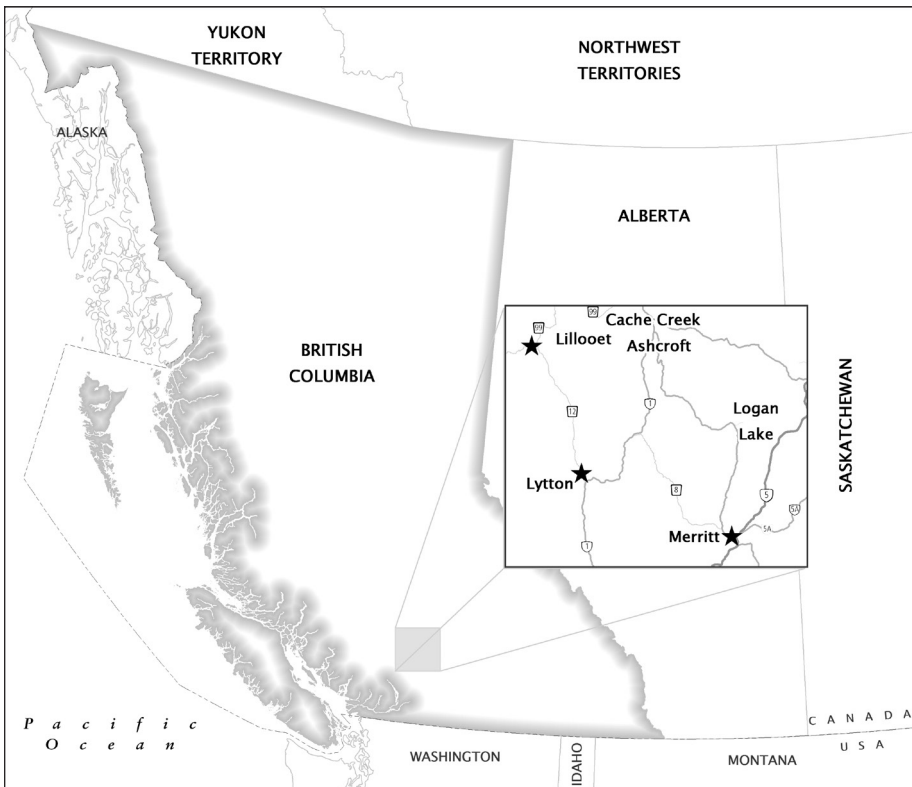
**Figure 1.** *Cerceris fumipennis* colony north of the Stein Valley Nlakapamux School, Lytton, BC.

**Table 2.** Site description of the 3 *Cerceris fumipennis* colonies in BC.

Site name	City	Date	Site type	Geographic coordinates (DD)	Elevation (m)
Central Park	Merritt	3 August 2012	Dirt path	50.11875N, -120.78348W	599
Stein Valley Nlakapamux School	Lytton	11 July 2014	Parking lot	50.27161N, -121.60358W	220
P'egg'ig'lha Community Centre	Lillooet	17 July 2014	Parking lot	50.67669N, -121.94610W	1136



**Figure 2.** *Cerceris fumipennis* colony adjacent to the P'eg'ig'lha Community Centre, Lillooet, BC.



**Figure 3.** Map showing the location of the 3 *Cerceris fumipennis* colonies.

is within the lower range of eastern specimens. Lytton and Lillooet occur within the Ponderosa Pine biogeoclimatic zone which is characterized by very warm, dry summers and cool winters with light snow cover (Anonymous 2007). Large diameter (+45 cm dbh) ponderosa pine, *Pinus ponderosa* Douglas ex. Lawson and C. Lawson (Pinaceae), is the most common tree at both sites, with declining and dead pine observed near the Lytton colony. Some hardwood trees were observed within a few hundred metres of the Lytton colony, while both sites also contained woody shrubs. The Lytton colony occurs at the junction of the northern portion of the Cascade Mountains and the eastern edge of the Coast Mountains. The Lillooet colony occurs within the eastern limits of the Coast Mountains while the Merritt colony lies within the Thompson Plateau (Holland 1976). Including the Merritt colony, a total of 99 sites was examined but only 3 *C. fumipennis* colonies have been discovered in BC resulting in a 3% success rate.

The following wasps were also collected in sweep nets at the 3 *Cerceris fumipennis* colonies. Crabronidae: *Bembix americana* Fabricius (Lytton), *Cerceris nigrescens* Smith (Merritt), *Ectemnius dilectus* (Cresson) (Merritt), *Philanthus multimaculatus* Cameron (Lytton), *Tachytes sayi* Banks (Lytton), and *Zanyssus texanus* (Cresson) (Lillooet). Chrysididae: *Parnopes edwardsii* (Cresson) (Lillooet). Halictidae: *Agapostemon* sp. (Merritt). Megachilidae: *Coelioxys* sp. (Lytton). Sphecidae: *Ammophila azteca* Cameron (Lytton). Vespidae: *Polistes dominula* (Christ) (Merritt, Lytton). However, *Cerceris californica* Cresson, another wasp known to prey upon buprestids (Scullen 1965) and previously recorded from British Columbia, was neither observed nor collected at any of the examined sites.

### Prey collected at nest entrances

The majority of jewel beetles were collected at the Merritt colony and included *Chrysothorhis leechi* Barr (Fig. 4), *C. laricis* Van Dyke, *Agrilus crataegi* Frost, *Phaenops drummondii* (Kirby) and *P. intrusa* (Horn). *Anthaxia caseyi caseyi* Obenberger was collected at the Lillooet colony. This specimen was discovered lying within a collapsed nest entrance covered with soil. Two other collapsed nest entrances were also covered by soil, but buprestid beetles were not observed.

### Nest excavation

A 30.5 × 30.5 × 20 cm hole was dug at the Lytton site. Between ground level and 10 cm below grade, fly pupae and other insect larvae were collected within 4 cells. Based on the presence of wasp cocoons and/or buprestids, *Cerceris fumipennis* cells were discovered from a depth of 10 to 20 cm. In total, 17 *C. fumipennis* cells were discovered, with most occurring 14 to 18 cm below the surface. Eleven cells contained a single *C. fumipennis* cocoon, but only fragments remained in the other cells. All cells with the exception of one located at a depth of 15.25 cm only contained buprestid body parts; primarily



**Figure 4.** Two discarded *Chrysobothris leechi* at 2 different nest entrances, 11 July 2014, Merritt, BC.

*Acmaeodera* spp. and *Phaenops* spp. elytra were uncovered. The jelly bean-shaped cell at 15.25 cm contained 4 buprestids wrapped together of which only 3 could be identified as *Phaenops gentilis* (LeConte). *Acmaeodera idahoensis* Barr and *P. drummondi* were also collected during excavation of this nest. One *Harpalus affinis* (Schrank) (Coleoptera: Carabidae) was discovered within another cell at 15.25 cm that also contained *Acmaeodera* spp. elytra. A similar sized hole was dug on 7 August 2015 at the Central Park colony. The first *C. fumipennis* cell was uncovered at a depth of 9.5 cm and the last cells were 15.3 cm below grade. Half the cells were located between 12.7 and 15.3 cm beneath the surface. In total, 23 *C. fumipennis* cells were uncovered of which 13 had intact cocoons (2) or cocoon fragments (11). Only the cells at 12.7 and 14 cm below grade contained intact buprestids, *Anthaxia caseyi caseyi*. Otherwise all other cells contained elytra or other buprestid body parts primarily belonging to *Agrilus* and *Anthaxia* spp. During nest excavation on 11 August 2014, intact specimens of *Agrilus granulatus populi* Fisher, *A. caseyi caseyi*, *Chrysobothris leechi* and *P. drummondi* were collected.

In total 9 buprestid species were collected at the Merritt, Lillooet and Lytton colonies (Table 3). The smallest beetle was *Anthaxia caseyi caseyi* (4.2 mm) while the largest was *Chrysobothris leechi* (12.0 mm). The average size of all buprestid prey from all 3 colonies is 8.8 mm. All beetles have been archived in the Pacific Forestry Centre Arthropod Collection (PFCA, Victoria, BC) which is part of Natural Resources Canada-Canadian Forest Service.

Silt comprised 66.6% of the soil from the Merritt colony, while sand comprised 59.6 and 80.9% of the soil from the Lillooet and Lytton colonies, respectively. Clay



**Table 3.** Average length of *C. fumipennis* prey from largest to smallest. Measurements were not recorded for *A. idahoensis* and *P. gentilis* as their heads were missing. \*New prey record for *C. fumipennis*.

Species	Average length (mm)
<i>Chrysobothris leechi</i> *	10.5 (n=10)
<i>Chrysobothris laricis</i> *	9.8 (n=1)
<i>Agrilus granulatus populii</i> *	8.7 (n=4)
<i>Phaenops drummondi</i>	8.2 (n=5)
<i>Phaenops intrusa</i> *	7.5 (n=1)
<i>Agrilus crataegi</i> *	6.7 (n=1)
<i>Anthaxia caseyi caseyi</i> *	4.7 (n=3)
<i>Acmaeodera idahoensis</i> *	N/A (1 specimen)
<i>Phaenops gentilis</i> *	N/A (3 specimens)

**Table 4.** Soil characteristics of the Lillooet, Lytton and Merritt colonies.

Site	Soil Texture			2 mm Sieve Pass %	Loss on Ignition %
	% Sand	% Silt	% Clay		
Merritt	11.6	66.6	21.8	100	2.2
Lillooet	59.6	34.1	6.3	99.3	2.0
Lytton	80.9	15.3	3.8	99.0	2.0

comprised 21.8% of the soil from Merritt, but only 3.8 and 6.3% of the soil from Lytton and Lillooet, respectively. All of the soil components from Merritt were less than 2 mm in any dimension, while 99 and 99.3% of soil constituents from Lytton and Lillooet passed through the 2 mm sieve. The organic content of all 3 soils is similar with 2.0 – 2.2 % loss on ignition (Table 4).

## Discussion

Lytton and Lillooet represent 2 newly discovered *Cerceris fumipennis* colonies in BC. Eleven other species of wasps, including *C. nigrescens*, were collected at the Merritt, Lillooet and Lytton colonies; yet *C. californica* was not among them. A tremendous amount of time and resources were used to examine multiple sites from 2012 to 2014, yet only 3 *C. fumipennis* colonies have been discovered, resulting in a 3% success rate. Compared to a 22% success rate in finding *C. fumipennis* colonies in Connecticut, North Carolina and Maine (Nalepa et al. 2012), it appears that colonies are less common in BC. The northernmost colony in Ontario is in Parry Sound District (MacDougall Public School, 45.39861°N) (P.D. Careless, personal observation) which is substantially further south than all 3 BC colonies. Lillooet (50.67669°N) represents the most northern North American colony to date. The annual number of degree days above 5 °C in Lillooet is 2387.8 compared to 1702.4 in Beatrice, ON, which is the weather station closest to Parry Sound (Anonymous 2015). As colonies can occur at



**Figure 5.** Red shale typically found in baseball fields in southwestern BC. Note 2 ant nests.

sites in Ontario that are cooler than Lillooet, there may be additional colonies further north in BC.

Unlike *Cerceris californica* in Washington state (Looney et al. 2014) or *C. fumipennis* in eastern North America (Nalepa et al. 2012; Careless et al. 2014), none of the BC colonies were discovered in baseball fields. Most baseball fields in southwestern BC are comprised of red shale containing many rock fragments which is likely a poor nesting substrate for *C. fumipennis* (Fig. 5). All 3 colonies occur within compact sand parking lots (Lytton and Lillooet) or compact silt pathways (Merritt) with full sun exposure throughout the day (Figs 1, 2). The colonies occur in the 2 biogeoclimatic zones, Bunchgrass and Ponderosa Pine, with the warmest and driest summers in BC. The Bunchgrass zone is generally characterized by widely spaced *Pseudoroegneria spicata* (Pursh) Á. Löve (bluebunch wheatgrass) and *Artemisia tridentata* Nuttall (big sagebrush) although ponderosa pine and Douglas-fir, *Pseudotsuga menziesii* (Mirbel) Franco (Pinaceae), also occur in this zone. The Ponderosa Pine zone consists of very open, park-like stands of ponderosa pine with an understory of bluebunch wheatgrass (Anonymous 2007). Both zones have a sparse distribution of trees, allowing many areas to receive full sun throughout many summer days. The nesting areas in Merritt and Lytton both occur on a slight incline that assists in drainage. There is very little similarity in soils between the 3 sites. Merritt is predominantly silt (66.6%) and has

the largest component of clay at 21.8%. Lytton is primarily sand (80.9%), and Lillooet is 59.6% sand and 34.1% silt. Further analysis is required to determine if there are specific constituents required for nesting or if there are other factors that play a more significant influence in nest site selection. Three additional sites in Merritt with suspect *Cerceris* entrance holes were excavated, but *Cerceris* nests were not present and the substrate consisted of substantially more and larger pebbles.

Recently, archived *Cerceris fumipennis* specimens have been discovered in the Wallis-Roughley Museum (University of Manitoba) and the Strickland Museum (University of Alberta). These specimens were collected in Spruce Woods Provincial Park, MB and Writing-on-Stone Provincial Park, AB and resemble the eastern race of *C. fumipennis* in size and colouration. Both sites are further south than the Lillooet colony. Perhaps *Cerceris fumipennis* is more cold tolerant than *C. californica*, thus explaining its distribution within many of Canada's provinces whereas the latter occurs in western North America where winters are relatively short and mild.

A total of 9 buprestid species were collected at the 3 *Cerceris fumipennis* colonies. *Chrysobothris leechi* was the most common intact beetle collected, followed by *Phaenops drummondi*, *Agrilus granulatus populi*, *Anthaxia caseyi caseyi*, and *P. gentilis*. Single specimens of *A. crataegi*, *P. intrusa*, *C. laricis* and *Acmaeodera idahoensis* were also found at these *C. fumipennis* colonies. During nest excavation, buprestid-filled *C. fumipennis* cells occurred between 10 and 20 cm below the surface which is similar to nests in eastern North America (Careless et al. 2009). Since wasp larvae feed on paralyzed prey, body parts were collected more often than intact beetles during nest excavation thereby making species-level identification difficult if not impossible. Many *Chrysobothris*, *Anthaxia* and *Acmaeodera* elytra were found in the cells which could alter the actual ratio of species preyed upon by *C. fumipennis*. Population size, predatory avoidance behaviour, size of the beetle, and other factors will affect whether or not a beetle is suitable prey for *C. fumipennis*.

The size of *Cerceris fumipennis* prey ranged from 4.2 mm (*Anthaxia caseyi caseyi*) to 12.0 mm (*Chrysobothris leechi*). *Chrysobothris leechi* was not only the most common intact beetle collected, but on average it was the largest species at 10.5 mm. In comparison, *Phaenops intrusa* comprised over 70% of the prey taken by *Cerceris californica* Cresson in southcentral Washington (Looney et al. 2014). In New York State, *C. fumipennis* captured prey ranging in size from 4.1 to 18.9 mm (Hellman and Fierke 2014); the latter is 57% larger than the *C. leechi* found at the Merritt colony. *Buprestis aurulenta* (Linnaeus) is a relatively common and large buprestid (12–20 mm) occurring in southern BC that breeds within Douglas-fir and ponderosa pine (Furniss and Carolin 1977), yet it was not collected at any of the *C. fumipennis* colonies. Although only a handful of *C. fumipennis* specimens have been collected in BC, females appear to be within the lower size range (wing length 9.5–10.5 mm; n = 6) of their eastern counterparts (wing length 9.5–13.5 mm; n = 75) (Kimoto and Buck 2015). There is a positive linear relationship between the size of *Cerceris arenaria* L. and *C. halone* Banks with the size of the prey weevils collected (Byers 1978; Polidori et al. 2005). The smaller size *C. fumipennis* from BC has likely contributed to the smaller prey items captured by provisioning females.

**Table 5.** Distribution and host records for *C. fumipennis* prey. Unless otherwise noted the information is based on Nelson et al. (2008). Some host names have been changed according to The Plant List ([www.theplantlist.org/](http://www.theplantlist.org/), accessed 3 March 2015).

Species	Distribution	Larval hosts
<i>Acmaeodera idahoensis</i>	BC, WA, OR, CA, ID, NV, MT, WY, UT	<i>Celtis occidentalis</i> <i>Cercocarpus ledifolius</i> <i>Crataegus douglasii</i> <i>Quercus garryana</i> *Adults occur on a variety of flowers, notably in the family Asteraceae.
<i>Agrilus crataegi</i>	transcontinental	<i>Amelanchier alnifolia</i> <i>Crataegus douglasii</i> (Westcott 2005)
<i>Agrilus granulatus populi</i>	NV (Solomon 1995), AB, BC, WA, OR, CA, ID, MT	<i>Populus trichocarpa</i> <i>P. nigra</i>
<i>Anthaxia (Haplantaxia) caseyi caseyi</i>	BC, WA, OR, CA, ID, MT, NV, AZ, UT	<i>Pinus coulteri</i> <i>P. ponderosa</i> <i>P. sabiniana</i>
<i>Chrysobothris laricis</i>	NWT, BC, AB, WA, OR, ID, MT, WY, UT, CO, NM, AZ	No larval host recorded; however, adults found on a variety of trees in the family Pinaceae.
<i>Chrysobothris leechi</i>	BC, AB, WA, OR, CA, ID, NV, MT	<i>Pinus aristata</i> <i>P. ponderosa</i>
<i>Phaenops drummondi</i>	transcontinental	A wide variety of trees in the family Pinaceae (MacRae and Westcott 2012).
<i>Phaenops gentilis</i>	BC, Rocky Mountain and Pacific States, NE, SD	<i>Pinus</i> spp.
<i>Phaenops intrusa</i>	BC, WA, OR, CA, ID, NV, MT, CO, AZ, NE, SD	<i>Larix occidentalis</i> <i>Pinus attenuata</i> <i>P. flexilis</i> <i>P. lambertiana</i> <i>P. ponderosa</i>

All of these beetles represent the first prey records for *Cerceris fumipennis* in BC. *Phaenops drummondi* is a known prey of eastern *C. fumipennis* (Paiero et al. 2012); however, all the other species and subspecies (i.e. *Agrilus granulatus populi*) are new prey records for this wasp. *Agrilus granulatus populi* and *P. intrusa* are also prey of *C. californica* in Washington state (Looney et al. 2014). Based on the list of prey species it is almost certain that female *C. fumipennis* forage on shrubs, conifers, deciduous trees and possibly flowers in BC (Table 5).

One ground beetle, *Harpalus affinis* was collected in a cell at 15.23 cm below grade along with the elytra of *Acmaeodera* spp. As other carabids were not discovered anywhere else in the nest it is uncertain if *Cerceris fumipennis* intentionally captured and provisioned the cell with this beetle. In 2009 and 2010, female *C. fumipennis* in Connecticut, Maine and New York captured 3 chrysomelids, *Neochlamisus bebbianae* (Brown), *Bassareus mammifer* (Newman), *Leptinotarsa decemlineata* (Say); 1 scarab, *Popillia japonica* Newman; and 2 cerambycids, *Saperda discoidea* F., *Oberea schaumii*

LeConte (Rutledge et al. 2011). *Neochlamisus bebbianae*, *B. mammifer* and *P. japonica* are shiny and similar in appearance to many jewel beetles, while *S. discoidea* and *O. schaumii* occur in tree canopies where *C. fumipennis* will forage. Therefore, collection of these non-prey items is understandable. *Harpalus affinis* is similar in length to some buprestids, however it looks different than most jewel beetles. Although adult *H. affinis* can fly, this specimen may have wandered into the nest entrance searching for prey or shelter. Until female wasps are intercepted carrying *H. affinis* back to their nests, this species can not be considered a prey item of *C. fumipennis*.

## Conclusions

Despite a significant amount of time spent searching many sites, only 3 *Cerceris fumipennis* colonies have so far been discovered in BC; they seem to be less common than colonies in eastern North America. A total of 9 buprestid species are recorded here as prey items of BC *C. fumipennis* and with the exception of *P. drummondi*, are all new prey records for this wasp. The prey ranged in size from 4.2 to 12.0 mm and seem to be smaller than prey collected by eastern wasps. *Cerceris fumipennis* in BC appear to be smaller than specimens occurring east of the Rocky Mountains which may contribute to the difference in size of prey collected.

## Acknowledgements

Tyler Kimoto assisted in excavating the Central Park, Merritt colony. Jeffrey Jarret (CFIA) identified *Harpalus affinis*. Darrell Finnigan, City of Merritt, provided permission to excavate the Central Park colony. Lee Humble, Natural Resources Canada – Canadian Forest Service, assisted in measuring buprestids. Mireille Marcotte, Robert Favrin and Wendy Laviolette, CFIA, provided financial and administrative support to conduct field work. Jacob Kanyaya, CFIA, generated the maps. Clive Dawson and Anette LaJeunesse, British Columbia Ministry of Environment, conducted soil analysis.

## References

- Anonymous (2007) Biogeoclimatic Ecosystem Classification Program. British Columbia Ministry of Forests, Lands and Natural Resource Operations. <http://www.for.gov.bc.ca/hre/becweb/resources/classificationreports/subzones/index.html> [accessed 11 May 2015]
- Anonymous (2015) Canadian Climate Normals 1981–2010 Station Data. Environment Canada. [http://climate.weather.gc.ca/climate\\_normals/index\\_e.html](http://climate.weather.gc.ca/climate_normals/index_e.html) [accessed 22 May 2015]
- Buck M (2004) An annotated checklist of the spheciform wasps of Ontario (Hymenoptera: Ampulicidae, Sphecidae and Crabronidae). *Journal of the Entomological Society of Ontario* 134 [2003]: 19–84.

- Byers GW (1978) Nests, prey, behavior and development of *Cerceris halone* (Hymenoptera: Sphecidae). Journal of the Kansas Entomological Society 51: 818–831.
- Careless PD (2010) Working with *Cerceris fumipennis* [online]. <http://www.cerceris.info> [accessed 2 October 2014]
- Careless PD, Marshall SA, Gill B, Appleton E, Favrin R, Kimoto T (2009) *Cerceris fumipennis* – A Biosurveillance Tool for Emerald Ash Borer. Canadian Food Inspection Agency, Ottawa, 16 pp.
- Careless P, Marshall SA, Gill BD (2014) The use of *Cerceris fumipennis* (Hymenoptera: Crabronidae) for surveying and monitoring emerald ash borer (Coleoptera: Buprestidae) infestations in eastern North America. The Canadian Entomologist 146: 90–105. doi: 10.4039/tce.2013.53
- Furniss RI, Carolin VM (1977) Western Forest Insects. U.S. Department of Agriculture, Forest Service. Miscellaneous publication No. 1339, 654 pp.
- Hellman WE, Fierke MK (2014) Evaluating buprestid preference and sampling efficiency of the digger wasp, *Cerceris fumipennis*, using morphometric predictors. Journal of Insect Science 14(4): 1–18. doi: 10.1673/031.014.04
- Holland SS (1976) Landforms of British Columbia. A Physiographic Outline. Bulletin 48. The Government of the Province of British Columbia, 138 pp. [accessed 12 May 2015]
- Hook AW, Evans HE (1991) Prey and parasites of *Cerceris fumipennis* (Hymenoptera: Sphecidae) from central Texas, with description of the larva of *Dasymutilla scaevola* (Hymenoptera: Mutillidae). Journal of the Kansas Entomological Society 64: 257–264.
- Kimoto T, Buck M (2015) Rediscovery of *Cerceris fumipennis* (Hymenoptera: Crabronidae) in British Columbia, with notes on geographic variation and nesting habits. The Canadian Entomologist 147: 419–424. doi: 10.4039/tce.2014.66
- Looney C, Hellman WE, Westcott RL (2014) Sampling Buprestidae (Coleoptera) in Washington state with *Cerceris californica* Cresson (Hymenoptera, Crabronidae). Journal of Hymenoptera Research 39: 83–97. doi: 10.3897/jhr.39.8026
- MacRae TC, Westcott RL (2012) Nomenclatural history of *Melanophila drummondi* ab. *nicolayi* Obenberger, 1944 (Coleoptera: Buprestidae), a change of authorship and synonymy under *Phaenops drummondi* (Kirby 1837), and a new distribution record and summary of larval hosts for the species. The Pan-Pacific Entomologist 88(1): 87–91. doi: 10.3956/2012-27.1
- Marshall SA, Paiero SM, Buck M (2005) Buprestid sampling at nests of *Cerceris fumipennis* (Hymenoptera: Crabronidae) in southern Ontario: the first Canadian records of three buprestids (Coleoptera: Buprestidae). The Canadian Entomologist 137: 416–419. doi: 10.4039/n05-016
- Marshall SA, Paiero SM, Buck M, Gill BD (2006) Using *Cerceris fumipennis* wasps to monitor the spread of emerald ash borer. In: Mastro V, Reardon R, Parra G (Eds) Emerald Ash Borer Research and Technology Meeting, Pittsburgh, September 26–27, 2005. U.S. Department of Agriculture, Forest Health Technology Enterprise Team.
- Nalepa CA, Teerling C, Rutledge CE, Swink W, Arellano C (2012) Ball diamonds as habitat for nests of *Cerceris fumipennis* (Hymenoptera: Crabronidae): Comparisons among three states. Journal of the Kansas Entomological Society 85(3): 219–225. doi: 10.2317/JKES120418.1

- Nelson GH, Walters Jr. GC, Haines RD, Bellamy CL (2008) A catalog and bibliography of the Buprestoidea of America north of Mexico. Coleopterists Society Special Publication 4: 1–274.
- Paiero SM, Jackson MD, Jewiss-Gaines A, Kimoto T, Gill BD, Marshall SA (2012) Field Guide to the Jewel Beetles (Coleoptera: Buprestidae) of Northeastern North America. Canadian Food Inspection Agency, 411 pp.
- Polidori C, Boesi R, Isola F, Andrietti F (2005) Provisioning patterns and choice of prey in the digger wasp *Cerceris arenaria* (Hymenoptera: Crabronidae): the role of prey size. European Journal of Entomology 102: 801–804. doi: 10.14411/eje.2005.111
- Rutledge CE, Hellman W, Teerling C (2011) Two novel prey families for the buprestid-hunting wasp *Cerceris fumipennis* Say (Hymenoptera: Crabronidae). The Coleopterists Bulletin 65(2): 194–196. doi: 10.1649/072.065.0223
- Rutledge CE, Fierke MK, Careless PD, Worthley T (2013) First detection of *Agrilus planipennis* in Connecticut made by monitoring *Cerceris fumipennis* (Crabronidae) colonies. Journal of Hymenoptera Research 32: 75–81. doi: 10.3897/jhr.32.4865
- Scullen HA (1965) Review of the genus *Cerceris* in America north of Mexico (Hymenoptera: Sphecidae). Proceedings of the United States National Museum 116: 333–548. doi: 10.5479/si.00963801.116-3506.333
- Solomon JD (1995) Guide to insect borers of North American broadleaf trees and shrubs. Agriculture Handbook 706. U.S. Department of Agriculture, Forest Service, Washington, DC, 735 pp.
- Westcott RL (2005) A new species of *Chrysobothris* Eschscholtz from Oregon and Washington, with notes on other Buprestidae (Coleoptera) occurring in the United States and Canada. Zootaxa 1044: 1–15.