

Year-to-Year Variation in Prey Capture by *Cerceris fumipennis* (Hymenoptera: Crabronidae) at Two Sites in North Carolina

WHITNEY G. SWINK,^{1,2} C. A. NALEPA,¹ AND J. P. BASHAM³

Ann. Entomol. Soc. Am. 107(6): 1121–1125 (2014); DOI: <http://dx.doi.org/10.1603/AN14068>

ABSTRACT *Cerceris fumipennis* Say is a solitary, ground-nesting wasp that preys exclusively on beetles in the family Buprestidae, including the invasive insect pest, emerald ash borer (*Agrilus planipennis* Fairmaire). Understanding patterns of *C. fumipennis* prey collection over time may improve use of the wasp as a biosurveillance tool for locating pest Buprestidae of economic concern. Here, we report on variation in prey capture by *C. fumipennis* at two sites in North Carolina over a 4-yr period. In total, 466 beetles were collected from the wasps from 2010 to 2013; these comprise 35 species, four new state records, six new prey records, and three native pests. Changes in prey capture from year to year at both sites suggest the importance of continued biosurveillance at sites with known wasp aggregations as emerald ash borer and other invasive pests spread into and throughout North Carolina.

KEY WORDS biosurveillance, Buprestidae, emerald ash borer, Hymenoptera

The invasive insect pest, emerald ash borer (*Agrilus planipennis* Fairmaire), was first introduced into the United States in 2002 and has since spread into 20 states, including North Carolina (Herms and McCullough 2014, U.S. Department of Agriculture [USDA] 2014). The beetle is responsible for killing millions of ash trees throughout the northeastern United States and Canada and measures to detect and control this exotic pest are being implemented. Early detection of emerald ash borer and similar pest buprestid species is crucial for efficient pest management.

Cerceris fumipennis Say is a native, ground-nesting wasp that preys almost exclusively on beetles in the family Buprestidae, including emerald ash borer (Marshall et al. 2005, Careless 2009). Since 2006, *C. fumipennis* has been used as a biosurveillance tool to detect species of economic importance such as emerald ash borer, *Agrilus sulcicollis* Lacordaire (European oak borer), and *Agrilus biguttatus* F. (oak splendor beetle), and to document local Buprestidae diversity (Swink et al. 2013, Careless et al. 2014, Hellman and Fierke 2014). The first recorded instance of emerald ash borer in Connecticut was one collected from *C. fumipennis*, supporting the use of the wasp as a biosurveillance tool (Rutledge et al. 2013).

To efficiently use *C. fumipennis* for pest detection, we need a better understanding of the wasp's foraging

behavior. As such, the goal of this study was to compare year-to-year *C. fumipennis* prey to detect patterns of location-specific prey use over time. Here, we report the variation in *C. fumipennis* prey collections at two sites in North Carolina over a 4-yr period.

Methods

***C. fumipennis* Biosurveillance.** *C. fumipennis* forms aggregations of between 5 and 500 independent nests in hard-packed, sandy soil with sparse vegetation in direct sunlight (Evans 1971, Careless 2009), features that are characteristic of campgrounds, dirt roads, and recreation fields used for baseball and softball (ball diamonds). Ball diamonds can be located using satellite imagery based on their recognizable color and shape; sites with potential for harboring *C. fumipennis* nest aggregations were identified using Google Earth (<https://www.google.com/earth/>). The wasps' nests are distinctive in appearance; nests have a circular mound of soil (tumulus) surrounding an entrance that runs perpendicular to the soil surface (Swink et al. 2013; Fig. 1). Depending on the location and year, the wasps emerge in May or June in North Carolina and forage for 5 to 6 wk after emergence (Careless et al. 2014).

Selected sites were surveyed for presence of *C. fumipennis* nests each year from 2010 to 2013 using methods described by Nalepa et al. (2012). Sites containing at least 15 nests were revisited to collect beetle prey from the wasps. Upon arrival at a site, discarded beetles on the ground in the vicinity of the nest entrances were collected. A sweep net was then used to collect beetles from foraging females returning to their nests, aided by using plastic collars over the nest entrance; these collars slow or prevent nest entry by

¹ Beneficial Insects Laboratory, North Carolina Department of Agriculture & Consumer Services, 1060 Mail Service Center, Raleigh, North Carolina, 27699-1060.

² Corresponding author, e-mail: whitney.swink@ncagr.gov.

³ Tennessee State University, College of Agriculture, Human, and Natural Sciences, Otis L. Floyd Nursery Research Center, 472 Cadillac Lane, McMinnville, Tennessee, 37110-1367.

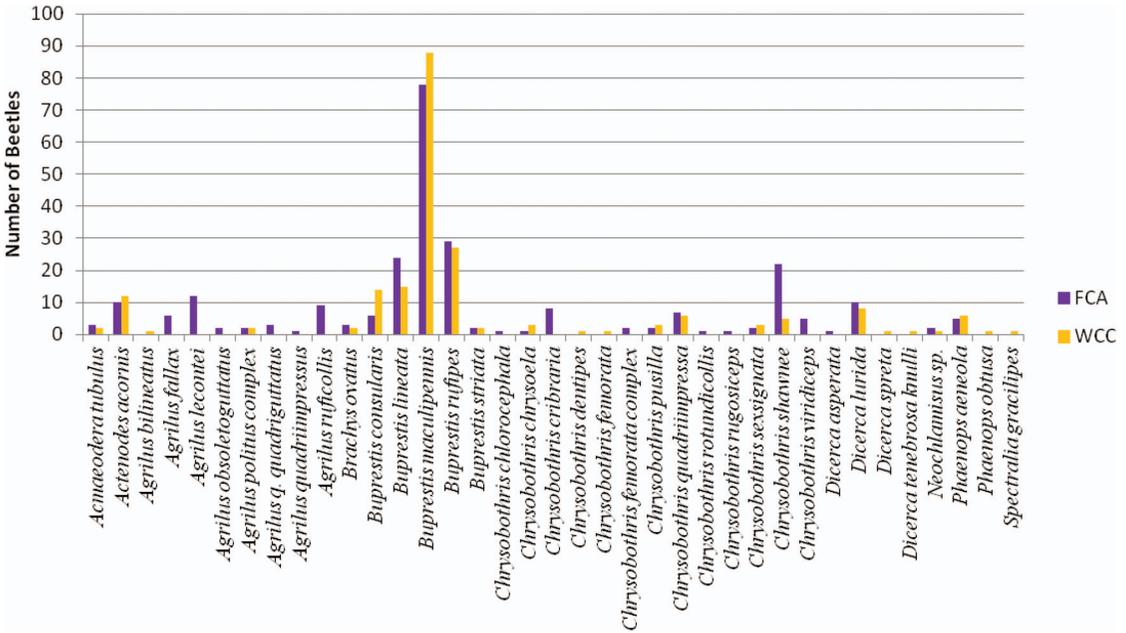


Fig. 1. The number of beetle species collected by *C. fumipennis* at FCA and WCC from 2010 to 2013.

a female carrying prey. For more detail see Careless et al. (2009), Swink et al. (2013), and Careless et al. (2014). The goal was to collect 40–50 beetles per site based on observations that this number represents the point of diminishing returns with regard to beetle diversity (Careless 2009). Each positive site was surveyed and beetles collected about once a week until there were no nests present or the wasps stopped actively foraging. Beetles were bagged and frozen when collected, then pinned, labeled, and identified to species by W.G.S. and J.P.B. Beetles have been deposited in the collection of the NC Department of Agriculture Beneficial Insects Laboratory (Cary, NC).

Year-to-Year Comparison. Sites were selected for year-to-year comparison of collected prey based on the following criteria: presence of *C. fumipennis* nests for all 4 yr of survey (2010–2013) and collection of at least 40–50 beetles at a given site for each year of the survey. Of the 480 sites surveyed as part of the North Carolina *C. fumipennis* biosurveillance program, only two sites met both criteria. Faith Christian Academy (FCA) is a private school with two adjacent ball diamonds and Wayne Community College (WCC) has one ball diamond. Both sites are located in Goldsboro (Wayne County) and are 7.2 km apart.

Results

Faith Christian Academy. In total, 260 beetles were collected at FCA from 2010 to 2013. Thirteen species were collected in 2010, 17 species were collected in 2011, 20 species were collected in 2012, and 16 species were collected in 2013 (Table 1). Two specimens were identified as belonging to the *Agrilus politus* (Say) complex and two specimens were iden-

tified as belonging to the *Chrysobothris femorata* (Olivier) complex (Bright 1987, Wellso and Manley 2007). Because these specimens could not be identified to species, they were not included in the total species count. Eight species were collected in just one of the 4 yr. Seven species were collected in all 4 yr. *Buprestis maculipennis* Gory represents 30% of the beetles collected, more than any other species (Fig. 1). *Chrysobothris* Eschscholtz was the most diverse genus collected over 4 yr (10 species) as well as the most diverse genus collected each individual year (equal to *Agrilus* Curtis in 2011 and *Buprestis* L. in 2013).

Wayne Community College. In total, 206 beetles were collected at WCC from 2010 to 2013. Nine species were collected in 2010, 12 species were collected in 2011, 13 species were collected in 2012, and 11 species were collected in 2013 (Table 1). In 2011, two specimens were identified as belonging to the *A. politus* complex (Bright 1987) and were not included in the total species count. Ten species were collected in just one of the 4 yr. Three species were collected in all 4 yr. The most frequently collected species was *B. maculipennis*, and *Chrysobothris* was the most diverse genus collected over 4 yr (seven species). *Buprestis* was the most diverse genus collected each individual year (equal to *Chrysobothris* in 2013).

Combined Analysis. In total, 466 beetles were collected at FCA and WCC from 2010 to 2013. *B. maculipennis* was collected more than any other species at both sites each year, with two exceptions. In 2010 and 2011 at FCA, *Buprestis rufipes* Olivier and *Agrilus lecontei* Saunders were the most frequently collected species, respectively (Fig. 2a). *Buprestis* was the most frequently collected genus with 61.2% (five species)

Table 1. Species of Buprestidae collected from *C. fumipennis* at FCA and WCC from 2010–2013

Species	2010		2011		2012		2013	
	FCA	WCC	FCA	WCC	FCA	WCC	FCA	WCC
<i>Acmaeodera tubulus</i> (F.)				✓	✓	✓		
<i>Actenodes acornis</i> (Say)	✓	✓	✓	✓	✓	✓	✓	
<i>Agrilus bilineatus</i> (Weber)								✓
<i>Agrilus fallax</i> Say	✓		✓					
<i>Agrilus lecontei</i> Saunders					✓			
<i>Agrilus obsoletoguttatus</i> Gory			✓					
<i>Agrilus politus</i> complex (Say)			✓	✓				
<i>Agrilus q. quadriguttatus</i> Gory			✓					
<i>Agrilus quadriimpressus</i> Ziegler					✓		✓	
<i>Agrilus ruficollis</i> (F.)			✓		✓		✓	
<i>Brachys ovatus</i> (Weber)				✓	✓		✓	✓
<i>Buprestis consularis</i> Gory	✓	✓	✓	✓	✓	✓	✓	✓
<i>Buprestis lineata</i> F.	✓	✓	✓	✓	✓	✓	✓	✓
<i>Buprestis maculipennis</i> Gory	✓	✓	✓	✓	✓	✓	✓	✓
<i>Buprestis rufipes</i> Olivier	✓	✓	✓	✓	✓	✓	✓	
<i>Buprestis striata</i> F.		✓	✓		✓		✓	
<i>Chrysobothris chlorocephala</i> Gory			✓					
<i>Chrysobothris chrysoela</i> (Illiger)						✓	✓	✓
<i>Chrysobothris cribraria</i> Mannerheim	✓		✓		✓		✓	
<i>Chrysobothris dentipes</i> (Germar)						✓		
<i>Chrysobothris femorata</i> (Olivier)								✓
<i>Chrysobothris femorata</i> complex			✓		✓			
<i>Chrysobothris pusilla</i> Gory & Laporte			✓	✓	✓			
<i>Chrysobothris quadriimpressa</i> Gory & Laporte	✓	✓	✓	✓	✓	✓		
<i>Chrysobothris rotundicollis</i> Gory & Laporte	✓							
<i>Chrysobothris rugosiceps</i> Melsheimer					✓			
<i>Chrysobothris sexsignata</i> Say	✓						✓	✓
<i>Chrysobothris shawnee</i> Wellso & Manley	✓	✓	✓	✓	✓		✓	
<i>Chrysobothris viridiceps</i> Melsheimer					✓		✓	
<i>Dicerca asperata</i> (Laporte & Gory)	✓							
<i>Dicerca lurida</i> (F.)	✓	✓			✓		✓	
<i>Dicerca spreta</i> (Gory)						✓		
<i>Dicerca tenebrosa knulli</i> (Kirby)						✓		
<i>Neochlamisus</i> sp. Karren					✓			✓
<i>Phaenops aeneola</i> (Melsheimer)			✓	✓	✓	✓	✓	
<i>Phaenops obtusa</i> (Horn)								✓
<i>Spectralia gracilipes</i> (Melsheimer)								✓

of total beetles collected at FCA and WCC from 2010 to 2013 (Fig. 2). The second most frequently collected genus was *Chrysobothris* at 15.9% (12 species) and the third was *Agrilus* at 8.2% (7 species). The remaining seven collected genera made up 14.8% of the beetles collected over the 4 yr at both sites. While *Buprestis* was the most frequently collected genus, *Chrysobothris* was the most diverse genus collected. All but one species collected at both sites were in the family Buprestidae. *Neochlamisus* sp. Karren (Chrysomelidae) is a known alternative prey of *C. fumipennis* and was collected by the wasp at FCA in 2012 and 2013 and WCC in 2013 (Scullen and Wold 1969, Rutledge et al. 2011, Swink et al. 2013).

Four species collected at these sites were identified as new state records for North Carolina. *A. lecontei* was first collected at FCA in 2011 and again in 2012 (Table 1). *Agrilus quadriimpressus* Ziegler was collected at FCA in 2012. *Buprestis consularis* Gory was collected in all 4 yr at both sites (Table 1). *A. lecontei*, *A. quadriimpressus*, and *B. consularis* were reported as new state records in Swink et al. 2013. Based on Nelson et al. (2008), the fourth new state record, *Phaenops obtusa* (Horn), was collected at WCC in 2013. The material examined is as follows: *Phaenops obtusa* (Horn). NORTH CAROLINA, Wayne Co., Goldsboro, Wayne Commu-

nity College, 35° 24'05" N, 77° 56'33" W, 16-VI-2013 (1), *Cerceris fumipennis* prey, C. A. Nalepa.

There were six new prey records for *C. fumipennis* collected at these sites. The following were reported as new prey records in Swink et al. 2013: *Acmaeodera tubulus* (F.) (collected at WCC in 2011 and at both sites in 2012), *A. lecontei*, and *A. quadriimpressus*. *Chrysobothris rugosiceps* Melsheimer was collected at FCA in 2012. *Chrysobothris shawnee* Wellso & Manley was collected in all 4 yr at FCA and in 2010 and 2011 at WCC. *P. obtusa* has been collected only at WCC.

Among the species collected, three are native pests: *Agrilus bilineatus* (Weber) (two-lined chestnut borer), *Agrilus ruficollis* (F.) (red-necked cane borer), and *C. femorata* (flat-headed appletree borer; Solomon 1995). One specimen of *A. bilineatus* was collected during the study at WCC. Nine *A. ruficollis* were collected at FCA from 2011 to 2013. *Rubus* sp. L., host of *A. ruficollis* (Nelson et al. 2008, Paiero et al. 2012, Harpootlian and Bellamy 2014), is a common shrub along the edge of the ball diamonds at FCA (Nalepa et al. 2013).

Discussion

The results of this study suggest the importance of repeat visits to a site with a known *C. fumipennis* nest

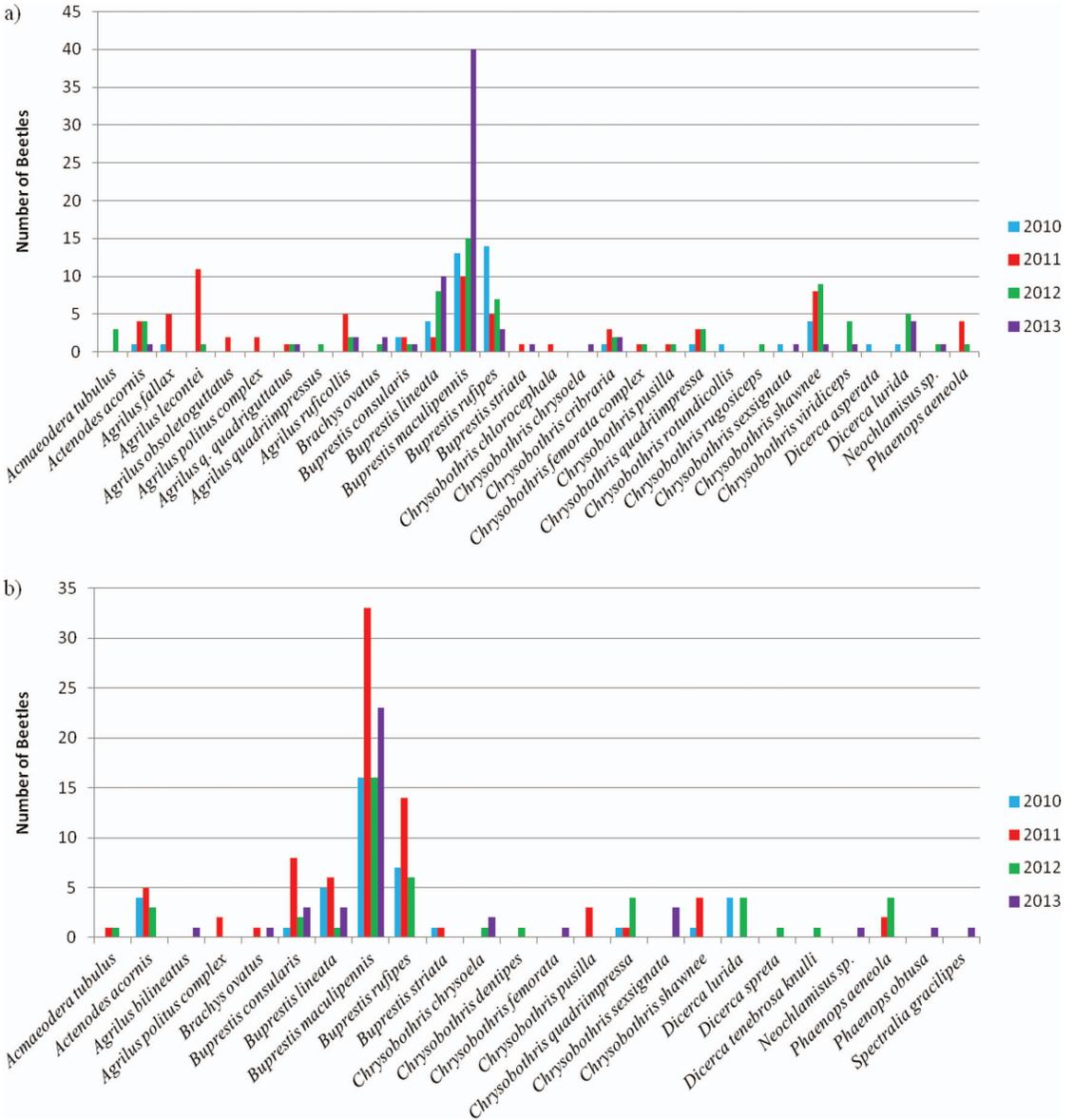


Fig. 2. Number of each beetle species collected by *C. fumipennis* for year-to-year comparison. (a) Species collected at FCA. (b) Species collected at WCC.

aggregation to obtain a complete picture of local buprestid diversity. At both FCA and WCC there were species collected in only 1 of the 4 yr of the survey, two of which were new records for the state (*A. quadrimpressus* and *P. obtusa*), and one of which was a federally recognized native pest, *A. bilineatus* (Haack and Acciavatti 1992). In addition, at both sites at least one species was collected each year that had not been captured in previous years (Table 1).

Changes in prey selection by the wasps may be influenced by a variety of factors. Adult *C. fumipennis* females are active for a single season, so each generation locates novel foraging sites (Linsley and MacSwain 1956, Evans 1971). Trees and shrubs visited by

wasps one year may not be visited the following year. Prey selection may depend upon local and temporal availability of the beetles as well as on wasp-specific characteristics such as body size and age (Polidori et al. 2007). Females likely return to a hunting site at which they have had initial foraging success. The wasps orient to their nests before making foraging trips; therefore, they likely orient to a successful foraging site. At both FCA and WCC, *B. maculipennis* was the most frequently collected species perhaps suggesting that the wasps located a hunting site with an abundance of prey and made successful return trips. However, there is enough variation among prey species to suggest that the wasp does not develop pref-

erences for particular prey taxa and hunts based on availability of prey. Other factors to consider include habitat preferences of the buprestid beetles and a relationship between wasp size and size of the prey (Linsley and MacSwain 1956). Prey that are abundant one year may experience population decline in subsequent years (Stubblefield et al. 1993). Because of the changes in prey availability and choice from year to year, continuing to survey *C. fumipennis* nest sites should be standard practice for effective use of the wasp as a biosurveillance tool.

Acknowledgments

We thank Walter Sloan and Don Magoon for permission to work on their ball diamonds, Rebecca Norris for help with beetle collection, and Stan Wells for help in identifying collected Buprestidae. This study was funded in part by Forest Health Protection, USDA Forest Service (10-DG-11083137-002) and the USDA Cooperative Agreement (12-8237-0889-CA). We appreciate the support of Don Duerr.

References Cited

- Bright, D. E. 1987. The metallic wood-boring beetles of Canada and Alaska (Coleoptera: Buprestidae). The Insects and Arachnids of Canada, Part 15. Agric. Can. Res. Br. Publ. 1810. Canadian Government Publishing Centre, Ottawa, Canada.
- Careless, P. D. 2009. Biosurveillance: Utilizing the beetle hunting wasp (*Cerceris fumipennis*, Hymenoptera: Crabronidae) to detect infestations of Emerald Ash Borers (*Agrilus planipennis*, Coleoptera: Buprestidae). Master's Thesis, Department of Environmental Biology, University of Guelph, Ontario, Canada. (<http://www.cerceris.info/literature.html>).
- Careless, P. D., S. A. Marshall, B. D. Gill, E. Appleton, R. Favrin, and T. Kimoto. 2009. *Cerceris fumipennis* – a biosurveillance tool for Emerald Ash Borer, p. 16. Canadian Food Inspection Agency, Guelph, Ontario, Canada.
- Careless, P. D., S. A. Marshall, and B. D. Gill. 2014. The use of *Cerceris fumipennis* (Hymenoptera: Crabronidae) for surveying and monitoring emerald ash borer (Coleoptera: Buprestidae) infestations in eastern North America. *Can. Entomol.* 146: 90–105.
- Evans, H. E. 1971. Observations on the nesting behavior of wasps of the tribe Cercerini. *J. Kans. Entomol. Soc.* 44: 500–523.
- Haack, R. A., and R. E. Acciavatti. 1992. Twolined chestnut borer. Forest Insect & Disease Leaflet 168, p. 12. U.S. Department of Agriculture, Forest Service, Washington, DC.
- Harpootlian, P. J., and C. L. Bellamy. 2014. Jewel Beetles (Coleoptera: Buprestidae) of South Carolina. South Carolina Agriculture Forest Research System. Clemson University, Clemson, SC.
- Hellman, W. E., and M. K. Fierke. 2014. Evaluating buprestid preference and sampling efficiency of the digger wasp, *Cerceris fumipennis*, using morphometric predictors. *J. Insect Sci.* 14: 4. (<http://www.insectscience.org/14.4>).
- Hermes, D. A., and D. G. McCullough. 2014. Emerald Ash Borer invasion of North America: History, Biology, Ecology, Impacts, and Management. *Annu. Rev. Entomol.* 59: 13–30.
- Linsley, E. G., and J. W. MacSwain. 1956. Some observations on the nesting habits and prey of *Cerceris californica* Cresson (Hymenoptera, Sphecidae). *Ann. Entomol. Soc. Am.* 49: 71–84.
- Marshall, S. A., S. M. Paiero, and M. Buck. 2005. Buprestid sampling at nests of *Cerceris fumipennis* (Hymenoptera: Crabronidae) in southern Ontario: the first Canadian records of three buprestids (Coleoptera: Buprestidae). *Can. Entomol.* 137: 416–419.
- Nalepa, C. A., C. Teerling, C. E. Rutledge, W. G. Swink, and C. Arellano. 2012. Ball diamonds as habitat for nests of *Cerceris fumipennis* (Hymenoptera: Crabronidae): Comparisons among three states. *J. Kans. Entomol. Soc.* 85: 219–225.
- Nalepa, C. A., W. G. Swink, P. Merten, and J. E. Moan. 2013. Conservative estimates of hunting distance in *Cerceris fumipennis* Say (Hymenoptera: Crabronidae). *J. Entomol. Sci.* 48: 299–305.
- Nelson, G. H., G. C. Walters Jr., R. D. Haines, and C. L. Bellamy. 2008. A catalog and bibliography of the Buprestoidea of America north of Mexico. Coleopterist's Society Special Publication, North Potomac, MD.
- Paiero, S. M., M. D. Jackson, A. Jewiss-Gaines, T. Kimoto, B. D. Gill, and S. A. Marshall. 2012. Field guild to the jewel beetles (Coleoptera: Buprestidae) of northeastern North America. Canadian Food Inspection Agency, Ottawa, Ontario, Canada.
- Polidori, C., R. Boesi, C. Pesarini, C. Papadia, S. Bevacqua, M. Federici, and F. Andrietti. 2007. Temporal Relationship between the Prey Spectrum and Population Structure of the Weevil-Hunting Wasp *Cerceris arenaria* (Hymenoptera: Crabronidae). *Zool. Stud.* 46: 83–91.
- Rutledge, C. E., W. Hellman, C. Teerling, and M. K. Fierke. 2011. Two novel prey families for the buprestid-hunting wasp *Cerceris fumipennis* Say (Hymenoptera: Crabronidae). *Coleopt. Bull.* 65: 194–196.
- Rutledge, C. E., M. K. Fierke, P. D. Careless, and T. Worthley. 2013. First detection of *Agrilus planipennis* in Connecticut made by monitoring *Cerceris fumipennis* (Crabronidae) colonies. *J. Hymenopt. Res.* 32: 75–81.
- Scullen, H. A., and J. L. Wold. 1969. Biology of wasps of the Tribe Cercerini, with a list of Coleoptera used as prey. *Ann. Entomol. Soc. Am.* 62: 209–214.
- Solomon, J. D. 1995. Guide to insect borers in North American broadleaf trees and shrubs. Agriculture Handbook 706, U.S. Dep. Agric. For. Ser., Washington, DC.
- Stubblefield, J. W., J. Seger, J. W. Wensel, and M. M. Heisler. 1993. Temporal, spatial, sex-ratio and body-size heterogeneity of prey species taken by the beewolf *Philanthus sanbornii* (Hymenoptera: Sphecidae). *Phil. Trans. R. Soc. Lond. B* 339: 397–423.
- Swink, W. G., S. M. Paiero, and C. A. Nalepa. 2013. Buprestidae collected as prey by the solitary, ground-nesting philantheine wasp *Cerceris fumipennis* (Hymenoptera: Crabronidae) in North Carolina. *Ann. Entomol. Soc. Am.* 106: 111–116.
- (USDA) U.S. Department of Agriculture. 2014. Emerald Ash Borer Report. U.S. Dep. Agric.-APHIS-PPQ 6: 1–11.
- Wells, S. E., and G. V. Manley. 2007. A revision of the *Chrysobothris femorata* (Olivier, 1790) species group from North America, north of Mexico (Coleoptera: Buprestidae). *Zootaxa* 1652: 1–26.

Received 8 May 2014; accepted 5 August 2014.