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Cerceris fumipennis – A Biosurveillance Tool for Emerald Ash Borer

1st Edition

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Canada

INDEX

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Primary Cover Image: *Cerceris fumipennis* with *Buprestis lineata* prey. Photo Courtesy of Brenna Wells.

Cerceris fumipennis – A Biosurveillance Tool for Emerald Ash Borer

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Cerceris fumipennis

BIOSURVEILLANCE

Nearly half a million square kilometres of quarantine zones across ten states and two provinces surround the Emerald Ash Borer (EAB), yet it continues to devastate eastern North America's ash trees, girdling and killing the host. EAB has proven difficult to detect using traditional methods of ground/visual surveys and sticky traps, both of which are costly, labour-intensive and at times destructive or impractical. Biosurveillance, using another species to survey for a pest species, offers an alternative approach for the detection and survey of EAB populations. We can now implement "biosurveillance" for EAB using a native wasp, *Cerceris fumipennis* (Say) in the solitary wasp family Crabronidae (Figure 1). This wasp provisions its nests strictly with buprestid beetle prey, with a host range now including the recently introduced EAB (Figure 2).

Preliminary studies have shown that the wasp's EAB detection skills far surpass any comparable human technology. *Cerceris fumipennis* has become a novel ally in our efforts to monitor for EAB in Canada and the United States.

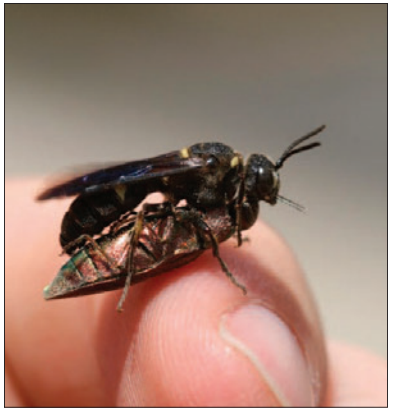

Figure 1. *Cerceris fumipennis with Dicerca prey. Photo courtesy of Michael Bohne.*

Figure 2. *Adult emerald ash borer (Agrilus planipennis).*

Cerceris IDENTIFICATION

Cerceris fumipennis, the only species of buprestid-hunting Crabronidae occurring in eastern North America, is found throughout the continental United States east of the Rockies: from Texas and Florida, north to Maine and Wyoming and is now known from more than twenty colonies of varying sizes in Canada (Figure. 3). The wasps are most often found nesting in open areas of hard-packed sandy soil surrounded by woody habitat suitable for their buprestid beetle prey. Ontario colonies are associated with somewhat disturbed sites compacted by human activity such as baseball diamonds, parking areas, infrequently used roads, roadsides, foot paths and the soil around campfire pits.

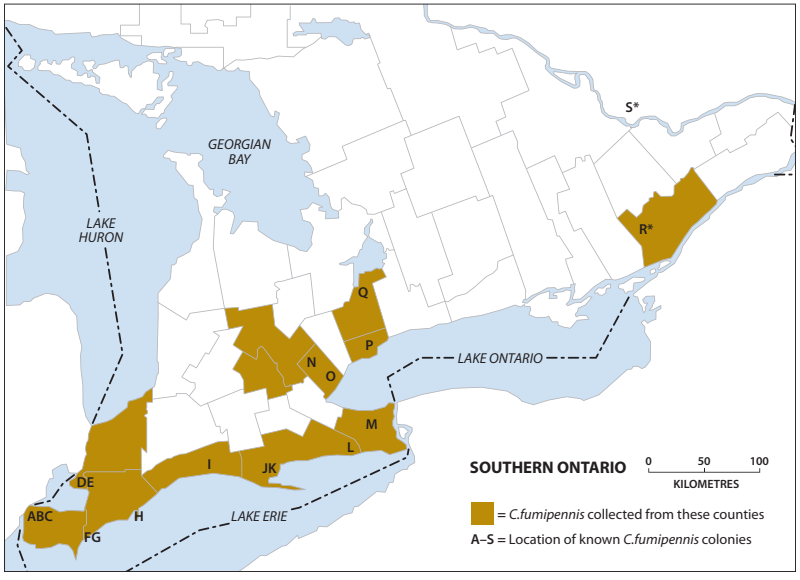

Figure 3. *Cerceris fumipennis distribution in Quebec and Ontario, September 2008.*

Cerceris fumipennis is distinguished by five conspicuous characteristics:

- It is large, about the size of common yellowjacket wasps.
- It has dark smoky, blue/black wings (i.e. *fumipennis*).
- The wasp's body is predominantly black except for a few yellow markings.
- It has a conspicuous, single broad creamy yellow abdominal band (Figure. 4).
- Females have three creamy yellow patches between the eyes (Figure 5); while males are marked with two yellow triangles abutting their eyes (Figure 6).

Figure 4. *Female Cerceris fumipennis. Note the single broad creamy yellow abdominal band.*

Figure 5.
Facial markings of a female Cerceris fumipennis.

Figure 6.
Facial markings of a male Cerceris fumipennis.

BIOLOGY

Cerceris fumipennis is a solitary ground-nesting wasp. Each lone female constructs and attempts to maintain a single subterranean nest for the duration of the flight season. Her solitary nest is in close proximity to others, forming a neighbourhood or informal colony of nests. The nest's entrance is easily visible, marked by a small circular mound of earth

Figure 7. *Typical Cerceris fumipennis nest entrance.*

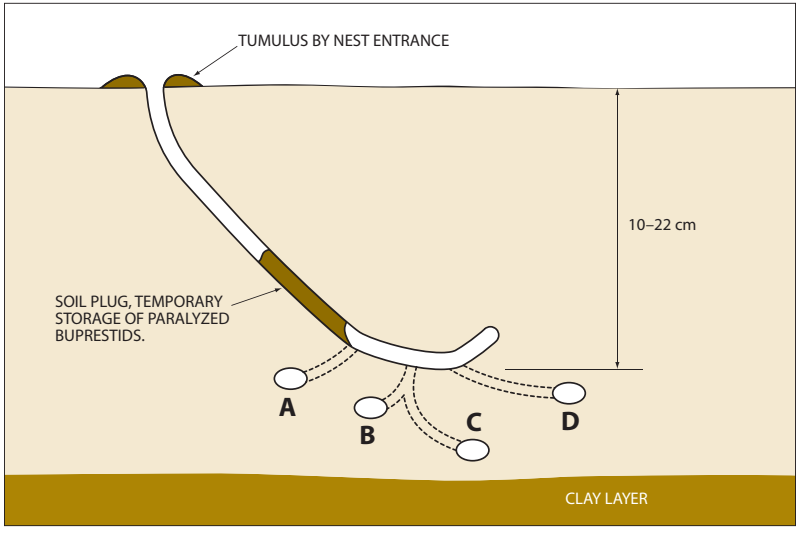

Figure 8. *Diagram of a Cerceris fumipennis nest. A, B, C and D indicate the location of completed cells; dotted lines indicate the sections of the main burrow that were backfilled upon the completion of each cell.*

(Figure 7). This hole leads into a vertical, pen-sized burrow that descends for about 3 cm before bending to a 45 degree angle and continuing downwards for a further 9 cm, at which point it levels out and becomes clogged with a loose sand plug (Figure 8). Paralyzed buprestid beetles are often temporarily stored in this sand plug.

A female wasp will typically attack a target beetle by alighting on it, climbing over it, and grabbing it by the thorax with her mandibles before inserting her stinger into the base of the beetle's leg (in the membrane of the coxal joint, a gap in the buprestid's armour) and injecting a paralytic venom. Once at the nest entrance or in the burrow, the female wasp will sometimes re-sting poorly paralyzed prey in the same joint. Buprestid beetles usually respond to disturbance by retracting their appendages and waiting for the danger to pass. This allows the wasp to carry a compact and motionless beetle into its nest.

Just beyond the loose sand plug is the current jelly bean-sized brood cell. The female wasp constructs and provisions only one cell at a time, so the number of completed cells surrounding a burrow provides an indication of how productive that wasp has been thus far in the flight season. Within minutes of placing the final paralyzed beetle into its subterranean cell the adult wasp lays a single hotdog-shaped egg along the beetle's mesosternum (Figure 9). Like many crabronid and sphecid wasps, *C. fumipennis* females stock their cells with all necessary food before laying an egg (this is called

Figure 9. *Cerceris fumipennis egg oviposited along the mesosternum of a Dicerca beetle.*

"mass provisioning"). Prey beetles are paralyzed, not killed, ensuring that each beetle will remain fresh until the wasp larva can begin feeding upon it. After the egg is laid, the completed cell is detached from the burrow as the female wasp backfills the access with 3 - 6 cm of soil. This reduces exposure to parasitoids and kleptoparasites (food thieves).

During the provisioning period, cells are often invaded by larvae of kleptoparasitic miltogrammine flies ("satellite flies"). Female flies intercept prey-laden wasps and deposit larvae or eggs on the paralyzed beetles. The voracious fly maggots out compete the developing wasp for the paralyzed beetles and the wasp larva dies of starvation.

Once one cell is completed the wasp begins work on the next cell by excavating in a new direction off the main burrow. Most cells (approximately 5 - 12, but up to 24) are constructed 7 – 20 cm below grade with the egg, larva and pupal stages all developing within the confines of the single nest. In Ontario, the period between oviposition and eclosion, which equals the duration of time spent in the brood cell, is about 10 months.

Emergence dates and speed of the life cycle vary across the wasp's broad distribution. In Ontario, the flight season typically begins during the last week of June and continues until early September. Emergence dates and duration of the flight season can be influenced by droughts, which could postpone emergence or shorten the flight season.

After tunneling up to the soil surface male wasps never re-enter a burrow. Emerging females use their emergence tunnels as new nests to which they conduct daily orientation flights. Each orientation flight begins with the female flying in ever-increasing arcs around its just-exited nest, often facing the nest while flying sideways. It is during this period that she familiarizes herself with immediate landmarks around her nest and more distant landmarks that will guide her back to the colony. The preferred landmarks are three-dimensional objects with broken silhouettes; the wasps often orient using multiple landmarks at a time. When the female is away foraging, the nest entrance remains open. Each female wasp will collect an average of two buprestids a day but in addition to these successful flights the wasps will often return from forays without prey, only to travel off on another foray moments later.

These seemingly unsuccessful flights may be a way for the wasp to practice its route back to the nest from various parts of its range. Reorienting itself over the landscape is particularly important as the wasp forages farther from its nest. Currently the maximum foraging range is estimated at 2 km with an estimated average flight distance of 750 metres from the nest. The fact that *C. fumipennis* diligently relearns and reorients to its surroundings bodes well for the success of mobile colonies.

During the Ontario flight season the first 7 - 10 days see significant new nest construction, low nest fidelity and high nest usurpation. A wasp will continue to excavate and provision new cells as long as she can retain ownership of a burrow. At most colonies, provisioning begins 3 - 5 days after females emerge from their cells, and continues for a 3 - 6 week period. Productive provisioning for Ontario's wasps starts at the beginning of July and then winds down near the second week of August, so Ontario's *C. fumipennis* are most useful for buprestid survey and EAB biosurveillance during July and early August.

"Nest fidelity" refers to the number of consecutive days during a flight season that a female remains faithful to maintaining and provisioning a single nest (approximately 1 - 49 days). Loose, dry sand filling in the nest entrance presents a challenge. If a cave-in occurs while the wasp is in the nest she can usually clear the sand block by pushing it out with her abdomen. If however, a wasp is trapped outside her nest by a cave-in of fine sand she may not be able to re-enter. Often this leads to "nest usurpation".

"Nest usurpation" occurs when a nestless wasp takes possession of an unguarded nest or she wins a standoff with the occupant. The displaced female wasp will eventually find and occupy an empty hole or displace another smaller female. Nest usurpation can result in a chain reaction of displacement; such chain reactions seem to be most common during the early emergence period and prolonged dry spells. Nest usurpation in *C. fumipennis* may be an adaptation to avoid digging through the hard or unstable surface soil.

MONITORING FOR EAB USING *Cerceris fumipennis* NESTS

By marking the wasps and nests, a human monitor at a colony can quickly and easily track the flights and successes of various wasps. Each wasp can be easily and safely handled as they rarely (never in our experience) use their stinger in defence. Wasps can be individually marked with a small dot of non-toxic paint dabbed on the top of the thorax (Figure 10) to facilitate the tracking of individual wasps and to allow the recording of foraging times and range. Nests can be marked and regulated using a "collar" made from a small 2 x 6 cm plastic or cardboard file card and a standard hole-punch. Holes are made on each end of the tab and it is secured over the nest entrance with a golf tee driven through one hole (Figure 11).

Figure 10. *Colour markings painted onto a female Cerceris fumipennis.*

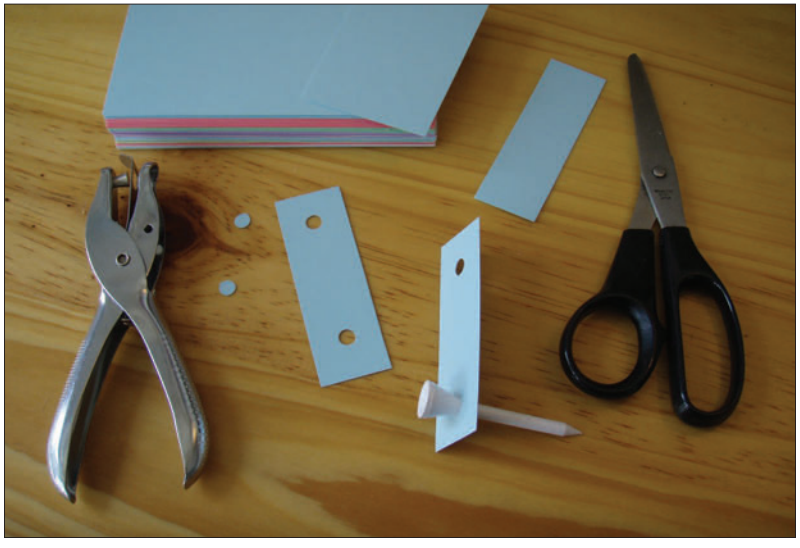

Figure 11.
Materials need to make a "collar", for placement over the entrance of a Cerceris fumipennis nest.

The collar's hole is large enough to allow wasps without prey to pass through uninterrupted but is small enough to prevent a female returning with prey from squeezing through. In response the wasp (reluctant to release its prey) will buzz and claw at the collar's opening, alerting a human monitor to the wasp's return (Figure 12). The bright green EAB adult prey is so distinctive it can be visually identified and then the collar can be moved to one side to allow the wasp to pass into the nest with her prey. Once the female wasp has entered, the collar is repositioned over the entrance and is ready for the wasp's subsequent exit and next successful return.

Figure 12. *This female Cerceris fumipennis, (returning with prey) is unable to pass though the "collar's" hole to her nest. This wasp has caught a male and female EAB in copula. The female beetle has been paralyzed by a sting from the wasp. The male beetle was not stung but is reluctant to break copulation – to his ultimate demise.*

HOW TO FIND *Cerceris fumipennis* COLONIES

Locating Colony Habitat

Cerceris fumipennis occurs in suitable habitats from Florida to southern Ontario. Follow these steps:

- Narrow your search area by checking for specimens in your local university or museum collections. If the collection is not well-curated you might have to pick the *C. fumipennis* out of unidentified material, which is generally easy because the males and females both have distinctive facial and abdominal marks (Figure 4, 5 and 6). These wasps are commonly collected on flowers some distance from their colonies, so collection records will give you a basic idea of where to start your search.
- Visit the locations on the specimen labels during the wasp's flight season and look for suitable nest sites. *Cerceris fumipennis* becomes active around the end of June in Ontario; earlier farther south. The wasps seem to prefer flat open sites exposed to full sunlight for most of the day.
- The ground should be hard-packed with relatively fine, sandy soil (exclude beaches and sand boxes). Sparse herbaceous vegetation is important so areas with a mixture of about 50% bare hard-packed sand and 50% short herbaceous vegetation are best (Figure 13). Focus on areas disturbed by humans: baseball diamonds, informal parking spots, infrequently used roads, sandy roadsides, foot paths and soil around fire pits or open campsites (Figure 14 and 15).

Figure 13. *Cerceris fumipennis nests at the Woodland Trails colony, Milton, Ontario, July 2007.*

Figure 14. *Cerceris fumipennis colony at Rondeau Provincial Park, Ontario, 2006.*

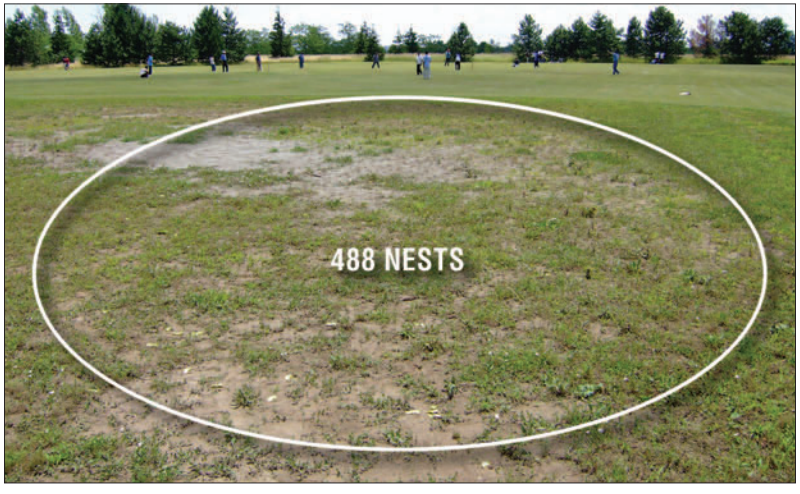

Figure 15. *Cerceris fumipennis colony at Bronte Creek Provincial Park, Ontario, 2006.*

- The buprestids being gathered by *C. fumipennis* are primarily arboreal and it is unlikely that the wasps would nest far from the "grocery store". Most known colonies are less than 200 m (200 yards) from a forested area.
- Avoid any freshly dumped mounds of soil or recently landscaped areas. The wasps overwinter approximately 15 cm below the soil surface and seem to build new nest chambers off the hole they emerged from earlier in the summer. For there to be a colony of suitable size the soil below 3 cm must have been left undisturbed for more than a year.

Finding Nests at the Site

After finding a promising colony habitat, you will need to locate the nests:

- Walk around any hard-packed, sparsely vegetated soil and look for nest entrances, which are often tucked beside a tuft of grass. Each digger wasp and bee creates their own telltale entrance. Some wasps cover up the openings but *C. fumipennis* makes a nice little round mound (approximately 4 cm in diameter) much like an ant mound (Figure 7). When you find mounds, check to see if they possess a round central entrance hole, which should travel straight down into the nest, not come in from a side location. The diameter of the hole should fit a golf pencil. A number of digger bees make circular mounds but the entrance holes are much smaller.
- Other insects are helpful indicators when trying to locate a *C. fumipennis* colony; all are taking advantage of similar soil and light conditions. Keep an eye out for digger wasps buzzing over the ground and excavating nests. Bee wolves (Figure 16), *Tachytes* wasps (Figure 17), other *Cerceris* species (Figure 18), digger bees (Figure 19), tiger beetles (Figure 20) and velvet ants (Figure 21) are found at many *C. fumipennis* colonies in Ontario.
- Dead buprestids lying around the nests or near the entrances are a good sign that you have found a colony, even if wasps are not active at the site. The female *C. fumipennis* are encumbered with some of the larger buprestid beetles. If the wasp feels threatened it will drop the large beetle. Without its prey, the urge to "get" a beetle seems to kick in and rather than picking up the dropped beetle, the wasp will head off to catch a new one.

Figure 16. *Bee wolf (Philanthus lepidus). Photo courtesy of Steve Marshall.*

Figure 17. *Tachytes wasp (Tachytes species).*

Figure 18. *Cerceris bicornuta (preys on weevils). Photo courtesy of Dave Cheung.*

Figure 19. *Digger bees (Colletes inaequalis). Photo courtesy of Steve Marshall.*

Figure 20. *Tiger Beetle (Cicindela punctulata).*

Figure 21. *Velvet Ant (Dasymutilla vesta). Photo courtesy of Steve Marshall.*

Confirming Nest Occupancy

To determine if the nest holes you have found are occupied by our wasp, try two tricks:

- Look down the burrow hole to see if a female is looking out. Often females wait 2 cm below the nest entrance to guard against other females that may want to take their nest. If the wasp looking back at you is a female *C. fumipennis* she will have a black head with three creamy yellow square patches in a V-shape in the middle of her face (Figure 5).
- If the hole is empty, place a clear plastic cup over the entrance with a stone on top to prevent the cup from blowing away (Figure 22). Check the cup every five minutes to see if a female is flying around it (Figure 23) or buzzing inside it. Do not leave the cups unattended for long periods, as wasps may over-heat and die on sunny days. By catching the female you can easily identify the species.

Figure 22. *Clear plastic cups over Cerceris fumipennis nests.*

Figure 23. *The nest of this female Cerceris fumipennis has been covered with a clear plastic cup. An observer can now identify the beetle being carried by the wasp and then move the cup, letting the wasp pass into her nest with the beetle.*

Marking Nests

If you plan to use the colony to check for Emerald Ash Borer, mark each new nest:

- Use cheap wooden golf tees and coloured collar tabs. Then if the entrance becomes obscured you will know exactly where the nest entrance should be. Writing the nest numbers on the top of the tee or collar will allow you to distinguish each nest.
- Use a GPS to record the geographical co-ordinates.

Final Thoughts

Finding the first colony will be the hard part but once you have found one colony you will begin to notice them elsewhere. If the wasps are present, you will see them. If they are not conspicuous, then search elsewhere.

Once you have found some colonies you may want to go back and revisit a few of your earlier sites. It is easy to overlook small colonies on days when they are not active such as after a heavy rain. Revisiting possible sites a week later is a good idea.

To optimize efforts you will want to work around the following schedule. In Ontario, the wasps are active from about June 28th to September 5th. There is only a single brood in Ontario but in southern Florida the wasp has two broods with the first one becoming active in early April. Observations in both Ontario and Florida suggest that the wasps rarely forage before 9:30 am and most females stop around 6:00 pm; females spend the night in their burrows. The wasps are more active on sunny days than cloudy days.

PROSPECTS FOR THE FUTURE

Biosurveillance requires the predator species to be available at all suspected areas of prey infestation. Naturally established colonies of *C. fumipennis*, while widespread in eastern North America, are only capable of foraging over a limited area and it is unlikely that there are enough well-placed natural colonies to use this as the primary surveillance tool within Canada and the US. Consequently, the development of mobile transplant wasp colonies could vastly improve the value of *C. fumipennis* as an EAB surveillance tool. Research is currently being conducted in this area.