Detection of Host Habitat by Parasitoids Using Cues Associated With Mycangial Fungi of the Mountain Pine Beetle, *Dendroctonus ponderosae*

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Detection of host habitat by parasitoids using cues associated with mycangial fungi of the mountain pine beetle, *Dendroctonus ponderosae*

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**Abstract**—Cues used by parasitoids to detect habitat of the mountain pine beetle, *Dendroctonus ponderosae* Hopkins (Coleoptera: Curculionidae), were investigated by observing parasitoid attraction to logs infested with *D. ponderosae*, logs inoculated with one or both of the symbiotic fungi of *D. ponderosae* (*Grosmannia clavigera* (Rob.-Jeffr. & R.W. Davidson) Zipfel, Z.W. de Beer & M.J. Wingf. (Ophiostomataceae) and *Ophiostoma montium* (Rumbold) Arx (Ophiostomataceae)), logs containing no beetles or fungi, or empty screen cylinders. Captures of *Heydenia unica* Cook and Davis (Hymenoptera: Pteromalidae) and *Rhopalicus pulchripennis* (Crawford) (Hymenoptera: Pteromalidae) on logs with both *G. clavigera* and *O. montium* were greater than those from control treatments. These results suggest that characteristics of tree tissues simultaneously colonized by the two symbiotic fungi facilitate a detectable change in the volatile compounds released from *D. ponderosae*-attacked trees that may be used by parasitoids to locate hosts.

[Traduit par la Rédaction]

Natural enemies typically locate host habitat using chemical cues that are reliably associated with their host. Such olfactory cues may originate from host products such as frass (Sullivan et al. 2000) or pheromones (Payne et al. 1984), or from organisms associated with their host, including symbiotic microorganisms (Madden 1968) or plants fed upon by the host (Schnee et al. 2006).

Bark beetles (Coleoptera: Curculionidae: Scolytinae) are associated with fungi in the Ophiostomatales and include the genera *Ophiostoma*, *Grosmannia*, and *Ceratocystiopsis* and their anamorphs (Upadhyay 1981). In culture, these fungi produce a number of volatile compounds, including oxygenated monoterpenes, cyclic sesquiterpenes, hydrocarbons, and short-chain alcohols and esters (Hanssen 1993). These compounds could be detected and exploited by natural enemies attacking bark beetle larvae. Bark colonized by *Ophiostoma* spp. associated with the bark beetles *Ips grandicollis* (Eichhoff) and *Dendroctonus frontalis* Zimmermann was attractive to the parasitoids *Roptrocerus xylophagorum*.
were taken from four beetle-free blocks assigned at random to traps and re-randomized less than 30 m apart. Treatments were initially transect parallel to the slope. Blocks were no closer than 3 m to infested trees along a line. Sticky-trap experiment was established with each block located in zones of infestation: (1) empty screen cylinders, (2) logs experimentally infested with D. ponderosae, (3) logs inoculated with fungi; however, the disks of malt extract agar were sterile. All logs were enclosed with fine-mesh screen. Screen cylinders without logs were used as controls. Logs and screen cylinders were placed in the field and enclosed with hardware cloth coated with aerosol Tape-Trap® (The Tanglefoot Company, Grand Rapids, Michigan). Captured insects were collected every 4 d from 7 July to 28 August.

Total numbers of parasitoids, by species, were summed over time within each block (n = 9) prior to one-way Kruskal–Wallis ANOVA on ranks (SigmaStat® version 2.03). Only captures of female parasitoids were analyzed. All post-hoc comparisons were made using Dunn’s method.

Captures of Heydenia unica Cook and Davis (Hymenoptera: Pteromalidae) and Rhopalicus pulchripennis (Crawford) (Hymenoptera: Pteromalidae) on logs inoculated with both G. clavigera and O. montium were significantly greater than on controls (Dunn’s method, P < 0.01 for both tests). Parasitoid captures on logs with D. ponderosae brood, logs inoculated with G. clavigera, and logs inoculated with O. montium were not significantly different than on the screen control or beetle- and fungus-free logs (Fig. 1). Captures of Coeloides rufovariegatus Provancher (Hymenoptera: Braconidae) and Dendroseter scaber Muesebeck (Hymenoptera: Braconidae) did not differ significantly among treatments.
Release of oxygenated monoterpenes from beetle-infested trees is thought to be responsible for host-habitat detection by several parasitoid species (Pettersson 2001). Trees that are not colonized by beetles or fungi emit low levels of monoterpene hydrocarbons, whereas trees successfully attacked by bark beetles release oxygenated monoterpenes (Pettersson and Boland 2003). Release of oxygenated monoterpenes can result from microbial activity, including that of fungi (Leufvén et al. 1988), and thus account for attraction to logs containing both *G. clavigera* and *O. montium*. Alternatively, these compounds also form as a result of spontaneous resin oxidation (Birgersson and Bergström 1989). Resin oxidation would have occurred in all treatment logs used in this study, which may account for captures of parasitoids on logs without fungi (Camors and Payne 1972).

If fungi are the source of cues used to locate host beetles, then the most reliable signal should be produced by the most consistent associate of the beetles in both space and time. Since olfactory cues composed of many compounds have the potential to convey more information than cues consisting of one or a few compounds, the use of complex host-location cues may give parasitoids a greater capacity to distinguish profitable foraging sites.

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