APPLICATION OF ELIMINADE™ PARASITOID FOOD TO BOLES AND CROWNS OF PINES (PINACEAE) INFESTED WITH DENDROCTONUS FRONTALIS (COLEOPTERA: SCOLYTIDAE)

FRED M STEPHEN
Department of Entomology, University of Arkansas, Fayetteville, Arkansas, United States 72701

and LLOYD E BROWNE
Entopath, Inc., 3555 Timberlane Drive, Easton, Pennsylvania, United States 18045

The Canadian Entomologist 132: 983 – 985

The southern pine beetle, Dendroctonus frontalis Zimmermann, is native to pine forests of the southern United States. We describe here techniques for enhancing parasitoid efficacy by direct feeding of parasitoid adults. Our recent research suggests that feeding by female adult D. frontalis parasitoids is important for increased longevity (Mathews and Stephen 1997, 1999; Stephen et al. 1997), and we documented that, with parasitoid feeding, egg resorption decreases and development of new immature eggs increases (Hanano 1996). We suspect that food for D. frontalis parasitoids, in the form of nectar, pollen, or honeydew, is not always available in the forest. We are developing a commercial D. frontalis control strategy based on this assumption.

The basis for this program is to conserve parasitoid populations and increase their effectiveness by means of field-based applications of Eliminade™, a nutritionally complete and environmentally safe natural product from Entopath Inc. We have a formulation of Eliminade™ that is incorporated into plastic "paint balls" and can be rapidly applied from the ground to standing trees using paint-ball guns. In parts of this work, the formulation was also applied to tree crowns as a liquid from a helicopter.

The objective of our research was to increase the knowledge of where adult parasitoids forage and feed in D. frontalis infestations. Our approach was to apply Eliminade™ to the surface of tree boles and to foliage in the crowns of trees on which we believed D. frontalis parasitoid adults to be present. These trees contained D. frontalis immature brood in development stages from 4th instar to pupae. Infested trees at this stage of development are attractive to host-seeking adult parasitoids. We collected parasitoids on the bark surface of bole- and foliage-treated trees as they searched for suitable hosts.

Infestations of D. frontalis were located in the Oakmulgee Ranger District of the Talladega National Forest, Alabama (32°55'N, 87°21'W). Study sites were mixed hardwood–pine stands, with the primary pine species being loblolly pine, Pinus taeda (L.), although some longleaf pine, Pinus palustris (Mill.), and Virginia pine, Pinus virginiana Mill., were also present.

Ground-based applications were made using plastic balls filled with a formulation of 2.1 g Eliminade™ per ball. Dye was added to the food, to aid in monitoring food placement on the trees and to later confirm parasitoid feeding. Food balls were applied using Stingray® CO₂-powered semi-automatic rifles, with 200 paint ball magazines and "12 ounce" CO₂ cylinders for applying balls in the field. These rifles propelled the balls with sufficient force to cause rupture upon impact with a hard part of the tree and "splatter" the food. Two ground-based experiments applying food balls were made to boles and (or) crowns of 17 trees infested with D. frontalis during July 1999. Experiment 1

Author to whom all correspondence should be addressed (E-mail: f.stephen@uark.edu).
(9–12 July 1999) consisted of two treatments. On 9 July, 50 food balls were applied to the boles of four trees. Applications were made at 1-m intervals, beginning at a point on the bole 3 m above the ground and continuing up the tree bole to midcrown height. The second treatment (12 July 1999) consisted of 50 balls shot into the upper canopy of each of four trees, to splatter on the foliage. In Experiment 2 (28 July 1999), three trees were treated with 50 food balls to the crown, three trees with 50 food balls to the bole, and three trees with 50 food balls divided between crown and bole. Parasitoids were collected from the boles of treated trees on consecutive days following food application. Collections were made using a modified “dust buster” vacuum, powered by a 12-V battery. Captured parasitoids were subsequently dissected to detect the presence of Eliminate™ and dye in their guts.

Data from the ground-based treatments suggested that adult parasitoids were feeding in the pine-foliage canopy. Experiment 3 (15 August 1999) consisted of a helicopter application (Entopath Inc.) of 8 L of Eliminate™ to tree crowns in a 0.5-ha area infested with D. frontalis. The wand of a hand-held sprayer that had been adapted by removing the spray nozzle was held out of the ship’s door and injected two 3 mm diameter streams of food into the blade down-wash. This apparatus produced large droplets (1–4 mm in diameter). In the closed canopies, the foliage filtered out almost all the food. White cards attached to tree boles and on the ground received few food spots. On each of the 4 d following aerial treatment, parasitoids were collected from eight trees infested with late-larval and pupal stages of D. frontalis.

Analysis of the proportion of parasitoids collected that were positive for Eliminate™ was conducted by a two independent sample binomial test, using large-sample normal approximation (Snedecor and Cochran 1980).

Adults from all the common genera of D. frontalis parasitoids [all Hymenoptera, i.e., Coeloides Wesmael, Spathius Nees, Dendrosoter Wesmael, and Meteorus Holiday (all Braconidae); Eurytoma Illiger (Eurytomidae); and Roptrocerus Ratzeburg, Dinotiscus Ghesquiere, and Heydenia Förster (all Pteromalidae)] fed on Eliminate™, both on the bark surface of infested trees and on crown foliage. Ground-based application of Eliminate™ to the crown via food balls proved difficult; balls shot into the crown had to hit a branch to shatter and splatter food onto the foliage.

In Experiment 1, the proportion of parasitoids feeding in crown foliage (12%; n = 169) was lower (Z = 5.9644; P < 0.0001) than the proportion feeding on the tree bole (47%; n = 79). In Experiment 2, results indicated that more food may have splattered on the foliage than in Experiment 1, as the percentage of parasitoids that fed in the crown in Experiment 2 (74%; n = 69) was greater (Z = 9.3696; P < 0.0001). In Experiment 2, the proportion of adults that fed did not differ between the crown-only and bole-only applications (75%; n = 122; Z = -0.6188; P = 0.5359). Also in Experiment 2, the application to the bole plus the crown gave good results, averaging 76% (n = 184) feeding; however, this treatment was not different from either the ground-based bole application (Z = -0.3616; P = 0.7174) or the ground-based crown application (Z = -0.3580; P = 0.7203) alone.

For 4 d following helicopter application of Eliminate™ to tree crown foliage (Exp. 3), we collected individuals of all eight genera of the D. frontalis parasitoid guild from the boles of trees containing D. frontalis brood. On average, 74.3% (n = 514) of the parasitoids collected during this period had dye in their guts.

The average percentages of fed individuals resulting from the helicopter treatment were higher than those resulting from the ground-based crown treatment (Z = -14.1921; P < 0.0001) or the ground-based bole treatment (Z = -4.995; P < 0.0001) in Experiment 1, but were not different from those resulting from the crown-only (Z = -0.0724; P = 0.9426) or bole-only (Z = 0.8140; P = 0.4156) treatments in Experiment 2.
We believe that our research on the feeding behavior of *D. frontalis* parasitoids and the discovery that parasitoids forage in the tree canopy will lead to a new tactic for the direct control of bark beetles. Aerial application of pesticides has long since been dismissed as impractical, both from an ecological and an efficacious perspective. Efficacious technology does not exist for applying southern pine beetle semiochemicals to standing timber from the air as a means of suppressing pest populations or protecting trees. However, applying food to *D. frontalis* spots from the air could be done economically. Infested spots are discrete and often encompass only a few hectares. Enhancing the biological control of a native pest species through aerial application of food for its parasitoid guild would be environmentally benign, as well as technically and economically feasible.

Both authors recall John Borden as a graduate student at the University of California, Berkeley. John was as serious and hard working as a student as he has been as a teacher and scientist since those days. We acknowledge and applaud his remarkable contributions to forest entomology throughout the years and wish him the best in the future. We thank Vaughn Salisbury for his dedication in the laboratory and field, and also thank Dana Kinney, Steven Browne, and Kevin Dodds for assistance and expertise. Ed Gbur provided statistical advice. This research was funded, in part, by the University of Arkansas Agricultural Experiment Station and the Arkansas Forest Resources Center.