VERTICAL POSITION OF TRAPS INFLUENCES CAPTURES OF EASTERN CHERRY FRUIT FLY (DIPTERA: TEPHRITIDAE)

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The eastern cherry fruit fly, *Rhagoletis cingulata* (Loew), is an important late-season pest of cherries in the eastern and Midwestern United States (Bush 1966). Adults emerge from overwintering puparia in mid-June, mate on the host fruit, and lay eggs into cherries (Pettit & Tolles 1930; Boller & Prokopy 1976; Smith 1984).

Michigan produces approximately 75% of the total U.S. tart cherries, *Prunus cerasus* L., and 12% of the U.S. sweet cherries, *P. avium* (L.) L. (Anon. 2004). Zero tolerance standards for fly larvae in fruit require sensitive fly monitoring systems early in the growing season as part of integrated pest management (IPM) programs to prevent fruit infestation. To monitor *R. cingulata* flies, Pherocon AM boards are placed approximately 2.1 m (depending on the tree size) from the ground within the tree canopy. The yellow traps are typically baited with an ammonia and protein hydrolysate lure (Liburd et al. 2001), providing both visual and olfactory cues to attract flies. The first insecticide is applied after a single fly is captured on a monitoring trap.

Steady progress has been made in developing effective trapping systems for some important *Rhagoletis* pests of temperate fruit crops. Trap placement has been optimized for monitoring the apple maggot fly, *R. pomonella* (Walsh), (Reissig 1975; Drummond et al. 1984) and the blueberry maggot, *R. mendax* Curran (Liburd et al. 2000; Teixeira & Polavarapu 2001). The optimal position for traps to monitor *R. pomonella* is approximately 2.1 m above the ground (depending on the tree size) within the apple tree canopy (Reissig 1975; Drummond et al. 1984) and 0.25-0.5 m from fruit, while traps for *R. mendax* are most effective when placed within the top of highbush blueberry plants, *Vaccinium corymbosum* L., when the bushes are 1.5 to 2.0 m high (Liburd et al. 2000; Teixeira & Polavarapu 2001). To date, the optimal positioning of traps for monitoring *R. cingulata* has not been reported; however, based on studies of related fruit fly species, we hypothesized that the height of trap placement within the cherry tree canopy would affect captures of *R. cingulata* on monitoring traps.

In 2002 and 2003, trap heights were compared in mature, unmanaged tart cherry orchards located in southwestern Michigan (Van Buren Co.) with high populations of *R. cingulata*. The orchards used in these experiments contained unsprayed, mature trees approximately 4.6 m in height, and planted in a 2.4-m within-row by 6.1-m between-row spacing. This spacing allowed sunlight to reach the entire tree, rather than the topmost portion only. In addition, branches from adjacent trees did not overlap.

The effect of trap height on captures of *R. cingulata* was determined by placing unbaited Pherocon AM traps (Trécé, Inc., Adair, OK) at three positions midway between the tree trunk and outermost foliage of cherry trees. All traps were placed on the southwest side of trees. Three treatments were evaluated that included placing traps as follows: (1) below the tree canopy (approximately 1.2 m above ground), (2) at the standard trap height (approximately 2.1 m), or (3) in the top portion of the tree canopy (approximately 4.6 m). In order to obtain the highest trap position, traps hung at 4.6 m were suspended from a PVC pipe (1.4 m length and 6 mm diam.) affixed to a tree limb such that the traps were within the top portion of the cherry tree foliage midway between the trunk and the outermost foliage. Trees were selected randomly and a single trap was placed at one of the three positions in each tree. Treatments were arranged with a distance of at least 20 m between trees and 30 m between blocks. Foliage surrounding all traps was removed in a 0.5 m radius (Reissig 1975). Five replicates of each treatment were arranged in a randomized complete block design. Flies were counted and removed from traps weekly for six weeks in both years (17 June-30 July 2002 and 16 June-29 July 2003). To minimize position effects, all treatments were rotated one position clockwise after each weekly inspection.

Total fly captures on each trap across the season in both years were subjected to analysis of variance (ANOVA). To normalize the data, square root-transformation $(x + 0.5)^{1/2}$ was performed prior to analysis. Fisher's Least Significant Difference test (LSD, SAS Institute 2000) was used to separate mean differences among treatments (significance level $\alpha = 0.05$).

In 2002, captures of *R. cingulata* were significantly affected by trap location ($F = 79.2$; $df = 2,8$; $P < 0.05$), with more *R. cingulata* flies caught at 4.6 m within canopies of cherry trees than on traps placed at 2.1 m (standard trap height) or 1.2 m (Fig. 1A). Overall, more than three times the number of flies were captured on traps placed at 4.6 m compared with traps hung at lower positions. In 2003, captures of *R. cingulata* flies were significantly affected by trap location ($F = 27.0$; $df = 2,8$; $P < 0.05$). Significantly more flies were caught on traps hung at 4.6 m compared with traps placed at a 2.1 m or 1.2 m height (Fig. 1B).

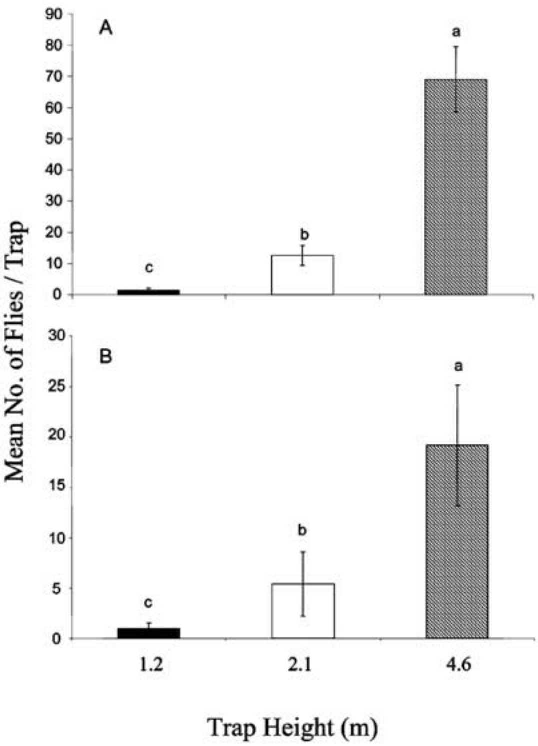

Fig. 1. Number of adult *R. cingulata* captured (± SEM) per season on Pherocon AM boards placed at low (1.2 m), standard (2.1 m), and high (4.6 m) positions within cherry trees. The experiment was conducted in 2002 (A) and 2003 (B). Means with the same letter within years are not significantly different (Fisher's LSD Test, $P < 0.05$). Untransformed means are shown.

Traps in the highest canopy position caught more than three times as many flies as those hung in either of the two lower canopy positions. During both years, the mean number of flies captured in the first week on traps at the high canopy position was greater than the 2.1- and 1.2-m canopy positions (respectively, in 2002: 49.2 ± 3.4, 9.8 ± 1.3, 1.0 ± 0.28; and 2003: 10.2 ± 2.4, 2.4 ± 0.9, 0.0).

Over two growing seasons, more *R. cingulata* were captured on traps placed at the highest position than on those hung at 2.1 m or 1.2 m. Similar results were obtained with *R. mendax* captures within blueberry bushes, where traps placed in the upper third of bushes captured the greatest number of flies (Liburd et al. 2000). In contrast, more *R. pomonella* were captured on Pherocon AM traps placed at 2.1 m within the canopy of apple trees than on traps at 1.2 or 3.0 m (Reissig 1975; Pelz et al. unpublished). Observations of adult *R. indifferens* revealed that the majority of flies were present within three meters of the ground (Frick et al. 1954). Differences in the distribution of fruit fly species within their host tree have also been reported for several tropical fruit flies in the genus *Anastrepha* (Sivinski et al. 2004). Within their respective host trees, *A. alveata* Stone are more abundant in the lower canopy of trees, while *A. striata* Schiner are more abundant in the upper canopy.

Our results suggest that *R. cingulata* activity is greatest in the uppermost portion of the host tree canopy; thus, traps placed higher in the tree may be more visible to *R. cingulata* flies that are active in the upper canopy compared with those placed lower in the tree canopy. Direct observations of *R. cingulata* within cherry trees are necessary to determine whether the distribution of flies is greatest in the upper canopy and whether that distribution changes throughout the day. In addition, assessment of infestation rates at different levels may also be valuable in determining whether peak fly oviposition activity coincides with fly population distribution, as found for *R. indifferens* (Frick et al. 1954) and several *Anastrepha* spp. (Sivinski et al. 1999, 2004). In their study, Frick et al. (1954) found that infestation of sweet cherries by *R. indifferens* was greater in the lower canopy (less than two meters) compared with infestation high in the tree canopy (between two and nine meters).

Finally, the sensitivity and accuracy of monitoring for *R. cingulata* may be improved through trap placement in a location where flies are most abundant; however, because standard trapping methods utilize ammonium acetate lures, further work must be done to determine whether these lures will affect fly captures on traps at different heights.

Summary

In 2002 and 2003, we compared the effect of three trap heights on captures of *R. cingulata* in Michigan cherry orchards. Overall, significantly more flies were captured on unbaited Pherocon AM traps hung at 4.6 m in the canopy of cherry trees than on traps hung at 2.1 m or at a low position of 1.2 m, suggesting that *R. cingulata* is more abundant in the upper portion of the host tree canopy.

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