Effect of Trap Color, Bait, Shape, and Orientation in Attraction of Blueberry Maggot (Diptera: Tephritidae) Flies

OSCAR E. LIBURD, STEVEN R. ALM, RICHARD A. CASAGRANDE, AND SRIDHAR POLAVARAPU[1]

Department of Plant Sciences, University of Rhode Island, Kingston, RI 02881

J. Econ. Entomol. 91(1): 243–249 (1998)

ABSTRACT Yellow, green, red, and blue sphere traps (9 cm diameter) were equal to or better than Pherocon AM yellow board traps in attracting blueberry maggot, *Rhagoletis mendax* Curran, flies. Because the sticky surface area of the Pherocon AM yellow board trap is 1.6 times greater than the sphere, sphere traps captured more flies per unit area. Both sphere and yellow board traps baited with ammonia were significantly more attractive than unbaited traps, thus ammonia may be the primary cue in attraction over trap shape or color. Ammonium carbonate dissipated within 2 wk from polycon dispensers and improvements in dispensers may allow season-long monitoring of blueberry maggot flies. More female than male flies were captured on ammonia baited traps over the season, which is consistent with findings that *Rhagoletis* female flies seek a protein source for egg maturation. A shift from yellow boards to spheres as the season progressed was not observed.

KEY WORDS *Rhagoletis mendax*, ammonia baits, traps

THE BLUEBERRY MAGGOT, *Rhagoletis mendax* Curran, is generally considered the most important insect pest of commercially grown low- and highbush blueberries (*Vaccinium angustifolium* Aiton and *V. corymbosum* L., respectively) in the eastern and midwestern United States (Prokopy and Coli 1978). The standard method of control in highbush blueberries is to apply 3–5 insecticide treatments against the adults. At present the treatment program followed by most growers is designed to prevent any possible injury, regardless of whether or not maggot flies are actually present.

Prokopy and Coli (1978) showed that Pherocon AM yellow sticky boards positioned in a V orientation with the sticky side facing downward above the canopy (hereafter referred to as a V trap) and 7.5-cm-diameter red spheres were effective in capturing blueberry maggot flies in highbush blueberries. Although Wood et al. (1983) cited Prokopy and Coli (1978), they used the Pherocon AM trap in a Λ orientation for monitoring in lowbush blueberry fields and stated that "the existing sampling method for adults is therefore not sufficiently reliable to predict the need for treatment in all fields." Neilson et al. (1984) used red spheres and Pherocon AM yellow board traps in various orientations in lowbush blueberry plantings and again stated, "The use of either type of trap to monitor adult prevalence to determine the time and need for control treatments appears feasible, but will require further study to provide reliable indices of adult populations for predicting the need for treatments."

Geddes et al. (1989) confirmed the greater trap capture of V traps in a lowbush blueberry planting. Gaul et al. (1995) also confirmed the effectiveness of the V trap in lowbush blueberry plantings and found them to be a useful tool in determining the need for, and timing of controls for blueberry maggot adults within New Brunswick and Nova Scotia. Currently, the Pherocon AM yellow board is the most widely used trap for monitoring *R. mendax* populations in both highbush and lowbush blueberries.

Red spheres are currently used to monitor apple maggot, *Rhagoletis pomonella* (Walsh) flies, and green spheres to monitor walnut husk flies, *R. completa* Cresson, but green, blue, and yellow spheres have never been tested for attraction of blueberry maggot flies. Also, relatively few studies to date have compared commercially available sphere and Pherocon AM yellow board traps and ammonia lures to determine the most effective trap for monitoring and management of *R. mendax*. Duan and Prokopy (1995a, b) have shown that insecticide-coated spheres may be used in the future to control apple maggot flies. Blueberry maggot flies may be controlled similarly if an effective attractant sphere were available.

Improvements in monitoring traps should help reduce the uncertainties stated by Wood et al. (1983) and Neilson et al. (1984) and provide greater integration of control techniques as more information on *Rhagoletis* spp. becomes available. Our research goals were to compare traps that are com-

[1] Rutgers Blueberry and Cranberry Research Center, Penn State Forest Road, Chatsworth, NJ 08019.

mercially available for monitoring *R. mendax* and other *Rhagoletis* species with previously untested blue, green, and yellow spheres. We also wanted to compare commercially available ammonium acetate and protein hydrolysate baited Tangle-Trap with ammonium carbonate in polycon dispensers for attraction of flies. Our ultimate goal was to develop a sensitive trap-and-lure system that can be easily used by growers to monitor *R. mendax* populations.

Materials and Methods

Research in 1995 and 1996 was conducted at 4 highbush blueberry plantings in New Jersey and Rhode Island. The Chatsworth, NJ, sites consisted of 3-ha plantings of 'Elizabeth' used in 1995 and 'Bluecrop' used in 1996. The Kingston, RI, site was a 0.15-ha planting of 6 cultivars: Bluecrop, 'Bluetta', 'Darrow', 'Earliblue', 'Herbert', and 'Lateblue'. The Coventry, RI, site used in 1995 was a 1.5-ha commercial blueberry planting of 6 cultivars: Earliblue, Blueray, Bluecrop, 'Coville', 'Jersey', and Lateblue. A section of the Coventry, RI, site was used in 1996 and consisted of 3 cultivars: Earliblue, Blueray, and Bluecrop. The West Kingston, RI, site was a 1.5-ha commercial planting of 'Berkley' and 'Collins'.

Traps were hung ≈15 cm above the canopy of a single cultivar (New Jersey) or cultivars that had similar harvest dates (Rhode Island). Traps were arranged in a randomized complete block design (blocked by cultivars in Rhode Island), 4 replicates at all 4 experimental locations for the 1st experiment in 1995 and for the Kingston and Coventry sites in 1996. Five replicates were used for experiment 2 in 1995, and for the Chatsworth and W. Kingston sites in 1996. At the Chatsworth, NJ, site, traps were 24 m apart (21 m between blocks). In Rhode Island, traps were 6 m apart (6 m between blocks) at the Kingston site, and 8 m apart (8 m between blocks) at the Coventry and W. Kingston sites. Traps were checked twice weekly in New Jersey and 3 times weekly in Rhode Island for all experiments in 1995 and 1996. Traps were rerandomized weekly in all locations.

Experiment 1. This experiment consisted of comparing commercially available traps and lures with previously untested green and blue spheres in 1 location in New Jersey and 3 locations in Rhode Island in 1995. Treatments included standard Pherocon AM yellow V traps prebaited with 1.0 g ammonium acetate ($CH_3CO_2NH_4$) and 0.5 g protein hydrolysate (Trece, Palo Alto, CA), prebaited Pherocon AM yellow boards in a vertical orientation, yellow V traps (not prebaited) with 5.6 g of ammonium carbonate ($(NH_4)_2CO_3$) in a polycon dispenser (Great Lakes IPM, Vestaburg, MI), yellow boards (not prebaited) in a vertical orientation with 5.6 g of ammonium carbonate in a polycon dispenser, unbaited 9-cm-diameter green spheres (Great Lakes IPM, Vestaburg, MI), green spheres with 5.6 g of ammonium carbonate in a polycon dispenser, unbaited blue spheres (commercially manufactured green spheres that were first spray painted with Krylon Flat White 1502 then with True Blue 1910, Sherwin-Williams, Solon, OH), and blue spheres with 5.6 g of ammonium carbonate in a polycon dispenser. The polycon dispensers were attached to traps at the juncture where the wire that was used to hang the traps was connected to the trap. The sticky coating for all traps was 13 g Tangle-Trap per trap (Tanglefoot, Grand Rapids, MI) based on the average amount on 20 Pherocon AM yellow boards.

Experiment 2. The Chatsworth, NJ, and Coventry and W. Kingston, RI, sites were used in 1995 to conduct a 2nd set of experiments which compared the most effective traps from the 1st set of experiments. Thirteen grams of commercially prepared ammonium acetate and protein hydrolysate baited Tangle-Trap were applied to green and blue spheres. These traps were tested against commercially prepared Pherocon yellow V traps with 13 g of ammonium acetate and protein hydrolysate baited Tangle-Trap.

Experiment 3. Experiments conducted in 1996 were designed to test the significance of color, trap shape, and bait in attracting flies. All baited traps contained 13 g of Tangle-Trap with 1 g ammonium acetate and 0.5 g protein hydrolysate. Baited and unbaited Pherocon AM V traps, yellow (commercially manufactured red spheres that were first spray painted with Krylon Flat White 1502, then hand rubbed with Trece Yellow from Flint Ink, Detroit, MI), green, and red spheres (Great Lakes IPM, Vestaburg, MI) were set out in randomized complete block designs in Chatsworth, NJ, and Kingston, W. Kingston, and Coventry, RI. Trap and block spacing was the same as in 1995. Flies captured at the Chatsworth site were removed every 3–4 d, cleaned with Histo-Clear (National Diagnostics, Atlanta, GA), and sexed to determine the proportion of each sex captured throughout the season.

Data from all 3 experiments were square-root transformed (x + 0.5) and analyzed by analysis of variance (ANOVA) followed by mean separation using the least significant difference (LSD) test (SAS Institute 1989). The untransformed means and standard errors are presented in tables 1–3.

Results

Experiment 1. Experiments conducted in 1995 showed that Pherocon AM yellow V traps prebaited with ammonium acetate and protein hydrolysate captured significantly more *R. mendax* flies in 7 of 8 sampling periods across 4 locations than the same trap in a vertical orientation (Table 1). Ammonium acetate and protein hydrolysate baited Pherocon AM yellow V traps captured an average of 2.1 times as many flies as similarly baited traps in a vertical orientation over the entire trapping period in all locations. Green and blue spheres baited with ammonium carbonate, however, were as or more attractive than baited Pherocon AM yellow V traps in

Table 1. Attraction of adult *R. mendax* to ammonia baits in various trap designs, New Jersey and Rhode Island, 1995

Trap design/lure/orientation	Mean ± SEM no. flies per trap			
	Chatsworth, NJ		Coventry, RI	
	8–15 July	20–27 July	30 June–13 July	24 July–8 Aug.
Pherocon AM/standard/V	332.3 ± 69.2a	201.0 ± 58.1a	153.0 ± 34.0a	33.0 ± 6.3ab
Pherocon AM/standard/I	284.5 ± 30.6a	73.5 ± 4.2b	33.5 ± 17.4bc	7.8 ± 2.9cd
Pherocon AM/ammonium carbonate/V	232.8 ± 34.4ab	64.0 ± 10.7bc	59.0 ± 2.7b	72.8 ± 35.9a
Pherocon AM/ammonium carbonate/I	53.5 ± 23.2de	15.5 ± 4.9d	45.5 ± 8.1bc	13.3 ± 6.2bcd
Green sphere/unbaited	26.5 ± 5.0e	33.5 ± 2.7cd	25.0 ± 8.1bc	13.3 ± 3.7bcd
Green sphere/ammonium carbonate	150.5 ± 37.2bc	109.3 ± 16.9b	243.3 ± 121.6a	26.5 ± 7.3bc
Blue sphere/unbaited	19.0 ± 9.5e	17.8 ± 3.2d	18.0 ± 7.1c	2.8 ± 1.1d
Blue sphere/ammonium carbonate	106.8 ± 15.9cd	73.8 ± 4.5b	205.8 ± 20.2a	27.8 ± 8.5abc
	West Kingston, RI		Kingston, RI	
	5–19 July	21 July–3 Aug.	29 June–13 July	20 July–3 Aug.
Pherocon AM/standard/V	67.5 ± 19.1a	52.0 ± 9.9abc	23.3 ± 9.8a	26.0 ± 12.2a
Pherocon AM/standard/I	11.3 ± 4.2cd	13.0 ± 4.8d	3.0 ± 1.2bc	6.5 ± 1.7bc
Pherocon AM/ammonium carbonate/V	29.3 ± 13.0bc	62.5 ± 14.7ab	4.3 ± 0.9bc	19.3 ± 11.9ab
Pherocon AM/ammonium carbonate/I	7.3 ± 2.3d	39.3 ± 24.2bcd	0.5 ± 0.3c	4.3 ± 0.6bc
Green sphere/unbaited	17.5 ± 5.7bcd	57.0 ± 14.3abc	3.5 ± 2.2bc	0.3 ± 0.3c
Green sphere/ammonium carbonate	60.0 ± 21.4a	99.3 ± 26.6a	4.0 ± 0.7bc	7.5 ± 3.1bc
Blue sphere/unbaited	9.0 ± 3.0d	16.5 ± 4.0d	3.3 ± 0.9bc	1.8 ± 0.3c
Blue sphere/ammonium carbonate	30.5 ± 10.8b	25.5 ± 4.5cd	12.3 ± 5.9ab	7.8 ± 5.1bc

Means in the same column followed by the same letter are not significantly different, ($P = 0.05$, LSD test. All traps changed at the beginning of the trapping period indicated). $F = 21.1, 12.5, 15.4, 4.4, 8.6, 5.8, 3.5, 3.4$, respectively; df = 7, 21; $P < 0.01$, <0.01, <0.01, <0.01, <0.01, <0.01, $=0.01$, $=0.01$, *respectively. V, traps in a V orientation with sticky surface facing down; I, traps in a vertical orientation with* sticky surfaces back-to-back; standard lure, ammonium acetate + protein hydrolysate.

4 of the 8 monitoring periods in the 1st experiment (Table 1). Ammonium carbonate baited Pherocon AM yellow V traps captured an average of 3.0 times as many flies as similarly baited yellow traps in a vertical orientation over the entire trapping period in all locations. Ammonium carbonate baited green and blue spheres captured an average of 4.0 and 5.6 times, respectively, as many flies as the corresponding unbaited green and blue spheres over the entire trapping period in all locations (Table 1).

Experiment 2. Green spheres baited with ammonium acetate/protein hydrolysate were significantly more attractive than Pherocon AM yellow V traps baited with the same bait in two of three locations (Table 2). Blue spheres were equal to, or more attractive, than yellow V traps.

Experiment 3. Experiments conducted in 1996 showed that green, red, and yellow baited spheres were as or more attractive than baited Pherocon AM yellow V traps with the exceptions of yellow spheres during 28 June–17 July in W. Kingston and red spheres during 24 June–19 July in Coventry (Table 3). There were no significant differences among yellow, green, and red baited spheres for any sample period in any location except Coventry, RI. There were no significant differences between green and red unbaited spheres, and only in New Jersey were the unbaited yellow spheres not as attractive as unbaited green and red spheres. Baited yellow boards, and baited yellow, green, or red spheres were 6.0, 6.0, 4.3, and 4.1 times as attractive as corresponding unbaited traps, respectively.

Traps baited with ammonium acetate and protein hyrolysate captured more female than male flies throughout the season in Chatsworth, NJ (Fig. 1). The ratio of males to females was relatively consistent on all traps except toward the end of the season. Peak capture of flies on all traps occurred during 19–23 July (Fig. 1). The mean number of *R. mendax* flies captured on unbaited traps on any collection date rarely exceeded 10 flies per trap (Fig. 1). As with baited traps, however, more females than male flies were captured on unbaited traps.

Table 2. Comparison of baited boards and spheres for captures of adult *R. mendax* in New Jersey and Rhode Island, 1995

Trap design/lure/orientation	Mean ± SEM no. flies per trap		
	Chatsworth, NJ 21 July–2 Aug.	Coventry, RI 14 July–11 Aug.	West Kingston, RI 16 July–11 Aug.
Pherocon AM/ammonium acetate + protein hydrolysate/V	279.5 ± 68.2b	115.6 ± 9.5b	25.2 ± 8.7ab
Green sphere/ammonium acetate + protein hydrolysate	475.8 ± 114.6a	211.0 ± 20.6a	42.6 ± 12.0a
Blue sphere/ammonium acetate + protein hydrolysate	382.8 ± 88.6a	107.8 ± 26.4b	16.2 ± 3.7b

Means in the same column followed by the same letter are not significantly different, ($P = 0.05$, LSD test). $F = 11.9, 16.3, 3.8$, respectively; df = 2, 6 (Chatsworth, NJ) 2, 8 (Coventry and West Kingston, RI); $P < 0.01$, <0.01, $=0.07$, respectively. V are traps in a V orientation with sticky surface facing down.

Table 3. Attraction of adult *R. mendax* to baited and unbaited yellow, green and red traps, New Jersey and Rhode Island, 1996

Trap design/lure/orientation	Mean ± SEM no. flies per trap			
	Chatsworth, NJ		Kingston, RI	
	25 June–12 July	16 July–9 Aug.	5–22 July	24 July–9 Aug.
Pherocon AM/ammonium acetate + protein hydrolysate/V	69.2 ± 14.0b	162.6 ± 21.1b	43.5 ± 14.3a	25.0 ± 7.4ab
Yellow sphere/ammonium acetate + protein hydrolysate	139.6 ± 20.0a	244.0 ± 41.7a	33.5 ± 2.6a	17.8 ± 5.3abc
Green sphere/ammonium acetate + protein hydrolysate	155.0 ± 33.4a	251.0 ± 30.5a	45.5 ± 6.9a	26.3 ± 6.0a
Red sphere/ammonium acetate + protein hydrolysate	166.2 ± 22.0a	264.4 ± 53.0a	30.0 ± 13.6ab	20.0 ± 5.7abc
Pherocon AM/unbaited/V	8.8 ± 2.8e	23.4 ± 7.1d	13.5 ± 5.8bc	4.5 ± 1.5d
Yellow sphere/unbaited	24.2 ± 9.6d	19.6 ± 6.5d	5.0 ± 0.7c	11.0 ± 2.2bcd
Green sphere/unbaited	42.8 ± 14.5c	52.6 ± 8.2c	10.3 ± 3.3c	13.5 ± 7.2bcd
Red sphere/unbaited	40.2 ± 6.8c	84.4 ± 15.4c	8.3 ± 1.3c	9.8 ± 3.5cd
	West Kingston, RI		Coventry, RI	
	28 June–17 July	22 July–9 Aug.	24 June–19 July	
Pherocon AM/ammonium acetate + protein hydrolysate/V	18.2 ± 5.7a	18.6 ± 5.7a	21.3 ± 6.6ab	
Yellow sphere/ammonium acetate + protein hydrolysate	7.6 ± 2.3bc	13.4 ± 3.1ab	22.3 ± 8.3a	
Green sphere/ammonium acetate + protein hydrolysate	14.0 ± 6.4ab	16.2 ± 3.7ab	16.8 ± 3.5ab	
Red sphere/ammonium acetate + protein hydrolysate	9.4 ± 2.1ab	10.8 ± 1.0abc	7.3 ± 3.4cd	
Pherocon AM/unbaited/V	2.2 ± 0.7cd	2.4 ± 0.6d	10.0 ± 3.4bc	
Yellow sphere/unbaited	1.2 ± 1.0d	3.4 ± 1.6d	4.0 ± 2.7cd	
Green sphere/unbaited	3.6 ± 1.8cd	5.8 ± 1.5cd	2.0 ± 1.35d	
Red sphere/unbaited	1.0 ± 0.8d	10.4 ± 3.9bc	1.3 ± 0.5d	

Means in the same column followed by the same letter are not significantly difference, (P = 0.05, LSD test). All traps changed at the beginning of the trapping period indicated. F = 49.5, 39.2, 6.3, 3.4, 7.3, 8.3, 7.5, respectively; df = 7, 28 (Chatsworth, NJ, and West Kingston, RI), 7, 21 (for Kingston and Coventry, RI), $P < 0.01$, <0.01, <0.01, =0.01, <0.01, <0.01, <0.01, respectively. V, traps in a V orientation with sticky surface facing down.

Discussion

Our results showed that significantly more flies were captured on Pherocon AM traps in a V than in a vertical orientation. The effectiveness of this configuration may be because of the preponderance of upward flights by *R. mendax* (Prokopy and Coli 1978, Smith and Prokopy 1981). Our data also suggest that green, red, yellow, or blue spheres baited with ammonium acetate and protein hydrolysate or ammonium carbonate can be as or more attractive than baited yellow board traps in a V orientation.

Because the surface area of the spheres used was 254 cm^2, and the surface area of the treated section of the yellow boards used was 394 cm^2, sphere traps were more attractive per unit area. The efficiency of sphere traps is even more evident when the disadvantage of lower total surface area, and therefore a possible lower amount of ammonia released, is taken into account. The high degree of attraction to spheres is even more dramatic if we consider the actual cross section surface area that the sphere displaces against a background (i.e., 64 cm^2), and that the total surface area of the yellow board is 644 cm^2. The importance of the 3-dimensional aspect of trap shape in attraction has been shown by Kring (1970) for *R. pomonella* and Riedl and Hislop (1985) for *R. completa*.

Significantly more flies were captured on ammonium acetate/protein hydrolysate baited green spheres than on baited Pherocon AM V traps in 1995 in New Jersey. All baited spheres in 1996 in New Jersey captured significantly more flies than baited Pherocon AM V traps. The New Jersey sites had larger fly populations and greater distances between traps, which were sufficient to show the differences between baited and unbaited traps. Therefore, trap shape and amount of ammonia released are likely the primary cues in attraction. Shorter distances between traps in Rhode Island experiments may account for the nonsignificant differences between yellow board and sphere traps. Prokopy and Coli (1978) found that unbaited 7.5-cm red spheres were as attractive as baited yellow panels. In their study, up to 3 traps were hung within the canopy of a single bush and some of these traps were only 1 m apart. Ammonia from yellow panels may have influenced captures on red spheres at this distance.

Another possible difference in experimental sites is that the New Jersey sites were in larger, more open areas than the Rhode Island sites. We noticed that yellow boards would move much more easily in the wind than sphere traps, which may also have negatively affected trap capture on yellow boards in New Jersey. Stabilizing traps might increase catch. Gaul et al. (1995) reported that Pherocon AM yellow board traps in a V orientation located in a sheltered site near berries captured 3 times as many

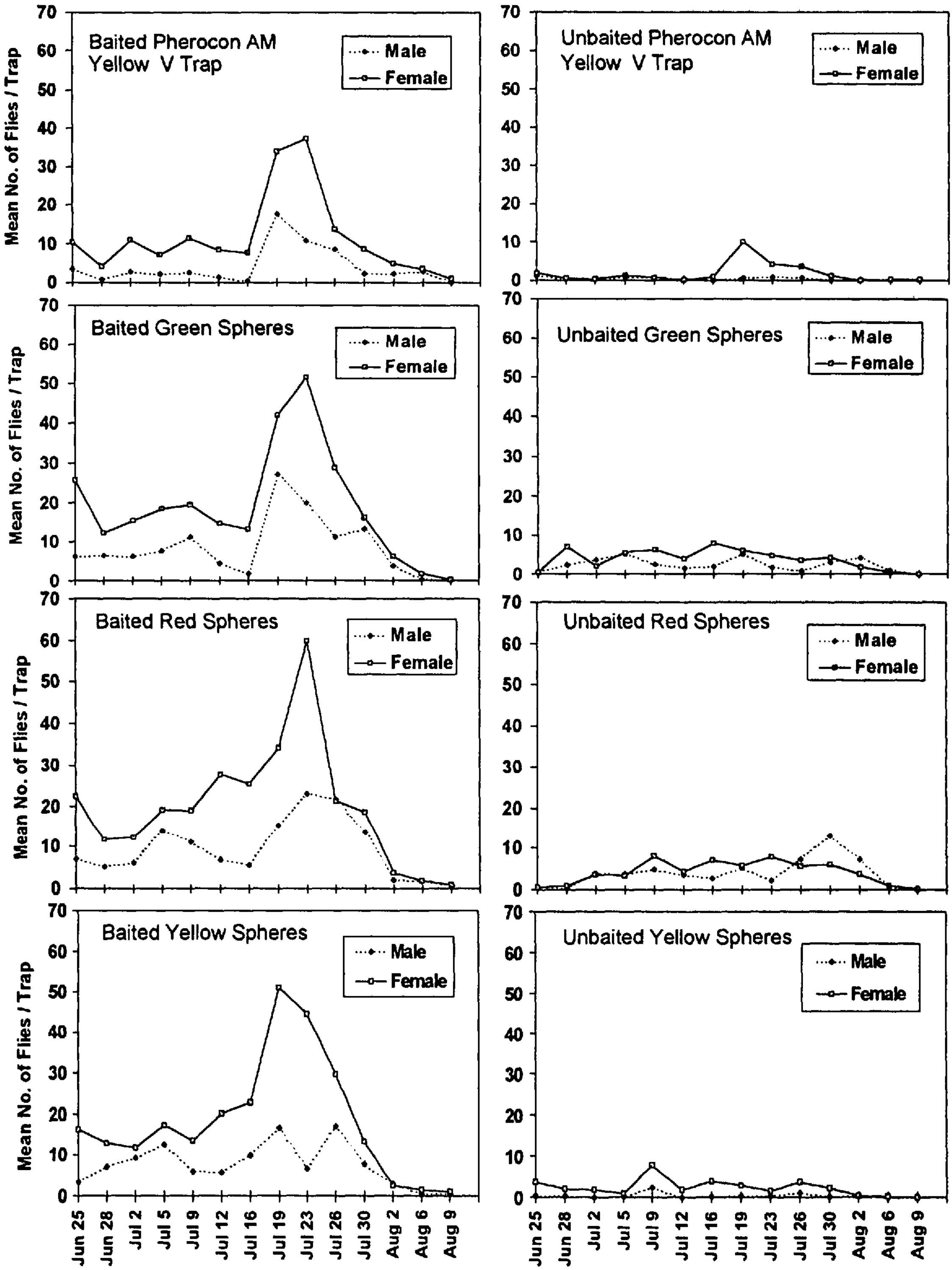

Fig. 1. Captures of male and female blueberry maggot flies on various color baited and unbaited traps, Chatsworth, NJ, 1996.

flies as traps located in an exposed site with no blueberries within 3 m of the trap.

Traps in the current study were hung above the canopy. Baited sphere traps placed within the canopy might be even more attractive and should be explored in the future. Drummond et al. (1984) showed that there was an optimal placement of traps within the canopy for attraction of apple maggot flies, *R. pomonella*. Reissig et al. (1984) also showed greater captures of apple maggot flies when traps were placed within the canopy than when hung on a wire trellis outside the canopy.

Ammonium carbonate in a polycon dispenser (5.6 g) was nearly completely dissipated by the end of 2 wk. Reynolds and Prokopy (1996) reported loss of 1.7 g of ammonium carbonate within 1 wk of deployment for traps for monitoring *R. pomonella*. They placed lures within 20 cm of the traps and found low attraction to traps near ammonium carbonate lures. They stated that ammonium carbonate should probably no longer be considered as a viable odor attractant for use with red sticky spheres in commercial orchards for trapping *R. pomonella*. We have shown that ammonium carbonate is attractive to *R. mendax* and can be useful for monitoring if the release of ammonia can be extended. Future research should concentrate on release rates of ammonia from ammonium acetate and ammonium carbonate from Tangle-Trap, polycon, and other dispensers.

Lathrop and Nickels (1932) determined male: female sex ratios of 1:0.83 ($n = 2,718$) and 1:0.76 ($n = 3,202$) from 2 yr of emergence cage data in Maine. Because more females than males were captured on traps in New Jersey in 1996, it is likely that females either live longer than males or are more strongly attracted to ammonia. These results are consistent with those of Neilson et al. (1984) who found more female than male *R. mendax* on both Pherocon AM traps and red spheres. These results are also consistent with Prokopy (1993), Prokopy and Roitberg (1989), and Prokopy et al. (1994), who showed that female *R. pomonella* flies seek a protein source for egg maturation.

The numbers and ratios of male and female flies captured on yellow, green, and blue traps in 1995 and yellow, green, and red traps in 1996 were similar throughout the season. Therefore, no differences in fly behavioral states (feeding versus oviposition) were observed during the season as has been reported for *R. mendax* (Smith and Prokopy 1982) and the sibling species *R. pomonella* (Prokopy and Roitberg 1989, Prokopy 1993, Prokopy et al. 1994). The response to ammonia was consistent across regions, and may have reflected a consistent hunger on the part of flies.

Frick et al. (1954) showed that yellow rectangles were more attractive to the cherry fruit fly, *R. cingulata* (Loew), than green, red, or orange rectangles. The hypothesis as to why yellow is so attractive is that yellow reflects light in the same part of the spectrum as foliage but at greater intensity (Riedl and Hislop 1985). Yellow represents a foliage-type stimulus to *R. pomonella* as well that elicits food and host-plant seeking behavior (Prokopy 1968, 1972). Red spheres, however, elicit an oviposition response from *R. pomonella* (Prokopy 1968).

Green spheres have been shown to be attractive to walnut husk flies, *R. completa* Cresson, and the lighter greens with equal or higher reflectance compared with the husk or foliage were more attractive (Riedl and Hoying 1981, Riedl and Hislop 1985). Yellow spheres were as attractive as green spheres to *R. completa* during the first weeks of emergence when reproductive activity was still low (Riedl and Hislop 1985). Red and blue spheres, however, were not attractive to *R. completa* (Riedl and Hislop 1985). Unbaited green and red spheres captured significantly more *R. mendax* flies than unbaited yellow spheres in New Jersey, but rarely so in Rhode Island. This can be explained, in part, if we consider green and red spheres as fruit mimics. Smith and Prokopy (1981) found that the majority of time spent by both sexes was on fruit. The nonsignificant differences between baited yellow, green, and red spheres indicate ammonia may be a stronger attractant cue than color for *R. mendax*.

The results of this study can be used immediately by growers to monitor blueberry maggot flies. The instructions provided with the yellow boards suggest hanging the trap in a vertical orientation. If Pherocon AM yellow boards are used, they should be in a V orientation with the sticky surface facing down. Spheres baited with ammonia can also be used. Extension and commercial catalog recommendations on the use of yellow boards and spheres can now be updated to include *R. mendax*. Recommendations should stress the importance of ammonia bait in the overall attraction of *R. mendax*.

Acknowledgments

We thank Heather Faubert, Jessica Kostarides, Derek Emery, Mark Webster, Lisa Tewksbury, Hua Peng, Jason Callahan, and Philip Ritz for technical assistance and Jack Partyka and John Macomber for the use of their blueberry plantings. We also thank Ronald J. Prokopy, A. Randall Alford, and Frank Drummond for critical review of the manuscript and Bill Lingren and Donna Petersen (Trece, Incorporated) for traps and lures. This research was partially funded by Northeast IPM grant 96-34103-3075. This is contribution No. 3484, Rhode Island Agricultural Experiment Station.

References Cited

Drummond, F., E. Groden, and R. J. Prokopy. 1984. Comparative efficacy and optimal positioning of traps for monitoring apple maggot flies (Diptera: Tephritidae). Environ. Entomol. 13: 232–235.

Duan, J. J., and R. J. Prokopy. 1995a. Development of pesticide-treated spheres for controlling apple maggot flies (Diptera: Tephritidae): pesticides and residue extending agents. J. Econ. Entomol. 88: 117–126.

1995b. Control of apple maggot flies (Diptera: Tephritidae) with pesticide-treated spheres. J. Econ. Entomol. 88: 700-707.

Frick, K. E., H. G. Simkover, and H. S. Telford. 1954. Bionomics of the cherry fruit flies in eastern Washington. Wash. Agric. Exp. Stn. Tech. Bull. 13.

Gaul, S. O., W.T.A. Neilson, E. N. Estabrooks, L. M. Crozier, and M. Fuller. 1995. Deployment and utility of traps for management of *Rhagoletis mendax* (Diptera: Tephritidae). J. Econ. Entomol. 88: 134-139.

Geddes, P. S., J.P.R. LeBlanc, K. L. Flanders, and H. Y. Forsythe, Jr. 1989. Installation of baited Pherocon AM traps for monitoring adult populations of *Rhagoletis mendax* (Diptera: Tephritidae) in lowbush blueberry fields. Environ. Entomol. 18: 510-512.

Kring, J. B. 1970. Red spheres and yellow panels combined to attract apple maggot flies. J. Econ. Entomol. 63: 466-469.

Lathrop, F. H., and C. B. Nickels. 1932. The biology and control of the blueberry maggot in Washington County, ME. U.S. Dep. Agric. Tech. Bull. 275.

Neilson, W.T.A., A. D. Knowlton, and M. Fuller. 1984. Capture of blueberry maggot adults, *Rhagoletis mendax* (Diptera: Tephritidae), on Pherocon AM traps and on tartar red dark sticky spheres in lowbush blueberry fields. Can. Entomol. 116: 113-118.

Prokopy, R. J. 1968. Visual responses of apple maggot flies, *Rhagoletis pomonella* (Diptera: Tephritidae): orchard studies. Entomol. Exp. Appl. 11: 403-422.

1972. Response of apple maggot flies to rectangles of different colors and shades. Environ. Entomol. 1: 720-726.

1993. Levels of quantitative investigation of tephritid fly foraging behavior, 165-171. *In* M. Aluja and P. Liedo [eds.], Fruit flies: biology and management. Springer, New York.

Prokopy, R. J., and W. M. Coli. 1978. Selective traps for monitoring *Rhagoletis mendax* flies. Prot. Ecol. 1: 45-53.

Prokopy, R. J., and B. D. Roitberg. 1989. Fruit fly foraging behavior, pp. 293-306. *In* A. S. Robinson and G. Hooper [eds.], Fruit flies: their biology, natural enemies and control. Elsevier, Amsterdam.

Prokopy, R. J., S. S. Cooley, J. J. Prokopy, Q. Quan, and J. P. Buonaccorsi. 1994. Interactive effects of resource abundance and state of adults on residence of apple maggot (Diptera: Tephritidae) flies in host tree patches. Environ. Entomol. 23: 304-315.

Reissig, W. H., R. W. Weires, C. G. Forshey, W. L. Roelofs, R. C. Lamb, H. S. Aldwinckle, and S. R. Alm. 1984. Management of the apple maggot, *Rhagoletis pomonella* (Walsh) (Diptera: Tephritidae), in disease-resistant dwarf and semi-dwarf apple trees. Environ. Entomol. 13: 684-690.

Reynolds, A. H., and R. J. Prokopy. 1996. Evaluation of odor lures for use with red sticky spheres to trap apple maggot flies. Fruit Notes 61: 1-2. University of Massachusetts, Amherst.

Riedl, H., and R. Hislop. 1985. Visual attraction of the walnut husk fly (Diptera: Tephritidae) to color rectangles and spheres. Environ. Entomol. 14: 810-814.

Riedl, H., and S. A. Hoying. 1981. Evaluation of trap designs and attractants for monitoring the walnut husk fly, *Rhagoletis completa* Cresson (Diptera: Tephritidae). Z. Angew. Entomolo. 91: 510-520.

SAS Institute. 1989. SAS/STAT user's guide, version 6, 4th ed., vol. 1. SAS Institute, Cary, NC.

Smith, D. C., and R. J. Prokopy. 1981. Seasonal and diurnal activity of *Rhagoletis mendax* flies in nature. Ann. Entomol. Soc. Am. 74: 462-466.

1982. Mating behavior of *Rhagoletis mendax* (Diptera: Tephritidae) flies in nature. Ann. Entomol. Soc. Am. 75: 388-392.

Wood, G. W., L. M. Crozier, and W.T.A. Neilson. 1983. Monitoring the blueberry maggot, *Rhagoletis mendax* (Diptera: Tephritidae), with Pherocon AM traps. Can. Entomol. 115: 219-220.

Received for publication 13 June 1997; accepted 14 October 1997