PEST MANAGEMENT

Relationship Between Plant Phenology and *Campylomma verbasci* (Hemiptera: Miridae) Damage to Apple Fruit

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ABSTRACT   Damage to apple (*Malus domestica* Borkhausen) by *Campylomma verbasci* (Meyer), has occurred even when effective insecticides are applied against nymphs present at the petal fall stage. However, insecticide application at pink bud prevents damage more effectively than when the same insecticides are applied at petal fall. We tested the hypothesis that most mullein bug damage occurs between bloom and petal fall by using two approaches. In the first, we caged naturally occurring nymphs on 'Red Delicious' limbs and restricted their possible infestation timing by applying insecticides both before cages were placed and also through the cage at various crop stages from bloom through fruit set. In a second approach, we caged Red Delicious and 'McIntosh' fruit clusters and introduced either small or large nymphs at various times from bloom through 3 wk after fruit set. Fruit damage on both varieties was greatest when small nymphs were introduced between bloom and petal fall; damage was uncommon from small nymphs introduced after fruit were ≈6 mm, and absent after the 13 mm size. However, damage was greater in cages into which large nymphs were introduced at 10–13 mm, than in untreated control cages. Fruit damage levels were equivalent on McIntosh and Red Delicious. We compared emergence of nymphs from McIntosh shoots with adjacent plantings of other, more susceptible cultivars by forcing hatch in the laboratory from cuttings collected in late winter. Significantly more nymphs hatched from susceptible varieties than from McIntosh, suggesting possible differences in levels of oviposition.

KEY WORDS   Miridae, *Campylomma verbasci*, apple, susceptibility, phenology

Campylomma verbasci (Meyer), a predatory mirid, has been recognized in Canada for a number of years as a pest capable of causing damage to apple (*Malus domestica* Borkhausen) fruit (Ross and Caesar 1920, Pickett 1938, McMullen and Jong 1970, Boivin and Stewart 1982). By 1991, *C. verbasci* had become an important pest of apple in Washington as well (Beers 1992). Although damage caused by this bug in New York and southern New England has been noted previously (Parrott 1913, Leonard 1965), reports of damage to apples in this region have become more numerous only since 1993 (Kain and Agnello 1998). *C. verbasci* damage also has recently been noted in the Netherlands (Stigter 1996), where it traditionally has been regarded as a beneficial predator. Another mirid, *Atractotomus mali* (Meyer), also has been noted in research plantings, but is generally much less numerous in western New York than *C. verbasci* (Kain and Agnello 1998). To date, *C. verbasci* remains a recurring pest in apple orchards important enough to warrant management recommendations in commercial production guidelines for New York (Agnello et al. 2012) and Washington (Bush et al. 2012), as well as British

Columbia (BC Ministry of Agriculture 2010), Ontario (Fisher 2012) and Québec (Cormier and Chouinard 2011), Canada.

During the 1993 season, in a number of research orchards, as much as 60% of all fruit at harvest exhibited mirid damage, even in plots receiving normal postbloom insecticide sprays. A number of commercial orchards in New York also have suffered severe damage since that time (Kain and Agnello 1998). *C. verbasci* and *A. mali* are beneficial most of the year, when they act as predators of mites and aphids (Bartlett 1996, Solymar 1999). However, they also feed on fruit, causing damage that is sporadic, but often severe. Injury first appears as a tiny pinprick on the fruit, surrounded by a water-soaked area that is not easily noticed. As the fruit enlarges, a raised, darkened, sometimes corky pimple forms on the fruit surface (Kain and Kovach 1998). Damage is most serious in Red Delicious, Golden Delicious, 'Spartan,' and 'Northern Spy' (MacPhee 1976, Thistlewood et al. 1989, Smith 1991, Reding and Beers 1996), although injury to other varieties occurs (Pickett 1938, Smith and Borden 1990, Solymar 1999). McIntosh is considered to be less susceptible to injury by mirids than the aforementioned cultivars (Smith 1991, Solymar 1999), although damage is known to occur (Thistlewood et

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al. 1989, Smith 1991). On any susceptible variety, much of the injured fruit will abort with the 'June drop' or, on some such as Red Delicious, the fruit will grow out of the injury (Thistlewood et al. 1989), but fruit remaining on the tree can be badly deformed.

Overwintered *C. verbasci* eggs usually hatch during full bloom of Red Delicious. Action thresholds for control of *C. verbasci* are generally based on limb-tap samples starting at bloom or petal fall and continuing for 2–3 wk (Solymar 1999). Many insecticides applied after bloom will kill *C. verbasci* nymphs that are present (Reding et al. 1992, Bostanian and Racette 2000). However, we have noted damage in research and commercial orchards when insecticides were applied at petal fall and either a short-lived insecticide or none was applied at the pink bud stage. Studies have shown that insecticides are most effective in preventing *C. verbasci* fruit damage when applied before petal fall (Reding et al. 1992, Reding and Beers 1996, Beers and Himmel 2001, Beers et al. 2002, Kain and Agnello 2002). Reding et al. (2001) showed that, on Red Delicious and 'Golden Delicious' in Washington, most injury occurs before petal fall, with very little or none occurring after fruit are 10–13 mm in diameter. This was the first report that the crop was susceptible only during this narrow time frame, as damage previously was thought to occur only after petal fall.

The relationship between crop phenology and insect development appears to be critical to the level of susceptibility of apple fruit to damage by mirid bugs. Because of significant differences in apple-growing regions between Washington and those in the eastern United States in orchard site characteristics, agroecosystem composition, and pest biology, we investigated the influence of phenology on incidence and severity of damage caused by *C. verbasci* in western New York. Specifically, we tested the hypothesis that most mirid damage occurs between bloom and petal fall. Our trials included Red Delicious, because this is the cultivar that most often suffers damage in our area, and McIntosh, which is usually not damaged.

Although our hypothesis was that the degree of synchrony between *C. verbasci* egg hatch and tree phenology is the primary reason for variation in varietal susceptibility to fruit damage, there also may be other factors involved (e.g., plant morphology, ability to harbor mirid prey, or egg survival). Therefore, we also examined whether there is greater *C. verbasci* oviposition on susceptible varieties than on McIntosh.

Materials and Methods

Timing of Fruit Damage by Naturally Occurring nymphs, 1996, 1998. Flower-bearing shoots on trees in a research orchard in Geneva, NY, were treated with insecticide at a number of specific phenological timings between full bloom and fruit set, and then caged to prevent further infestations by naturally occurring *C. verbasci.* At different stages of crop development, esfenvalerate (Asana XL 0.66 EC, E.I. du Pont de Nemours & Co., Wilmington, DE) was applied to 0.9–1.25-m sections of tree limbs (Red Delicious)

bearing flower clusters, which afterward were caged using nylon mosquito netting, to exclude nymphs originating from untreated parts of the tree. Esfenvalerate solution was applied to runoff with a backpack sprayer, at a rate of 89 ml/379 liter, at full bloom, petal fall, and when fruit were ≈10 mm. The bloom and petal fall treatments were also sprayed with esfenvalerate, through the mesh of the cage, at weekly intervals until fruit set (fruit 6–10 mm) to kill any later hatching nymphs inside the cage. This ensured that any damage occurring in a treatment would have had to occur before the time of the first esfenvalerate application (in the bloom treatment before full bloom, in the petal fall treatment before petal fall, and in the fruit set treatment before when fruit were 6–10 mm). No other insecticides were applied to test trees, but plots were treated as normal with fungicides and chemical thinning sprays. In rating the damage, fruit were categorized based on the number of mirid stings evident: 0–1, equivalent to U.S. Fancy grade; 2, U.S. #1; >2, Cull (New York State Dep. of Agriculture and Markets 1973). Drops found inside the mesh bag were counted. Percent drop was calculated as the number of drops divided by the total number of fruit. In 1998, the Fancy category was further separated into Clean (no mirid damage) and Fancy (one sting). Each treatment was replicated 16 times in a completely randomized design. Percent fruit damage in each grading category was calculated, transformed by arcsine square root and analyzed using analysis of variance (ANOVA). Means were separated using Fisher Protected least significant difference test ($P = 0.05$) (SuperANOVA version 1.11, Abacus Concepts 1991).

Damage by Introduced Nymphs, 1999–2000. In 1999, *C. verbasci* nymphs were hatched in a growth chamber (25°C, 60% RH, and a photoperiod of 16:8 [L:D] h) from apple cuttings collected in late winter and then stored in a refrigerated room (at 1°C) until ≈1 wk before the time of infestation, beginning 4 May. Cuttings were inserted into floral foam held in pans and saturated with water. Growth chamber conditions were 25°C, 60% RH, and a photoperiod of 16:8 (L:D) h. Nymphs (first–third instar) were collected by tapping onto a beating tray covered with black cloth and transferred using a camel-hair brush to fresh, unsprayed apple leaves, which were then introduced into organdy cages on Red Delicious and McIntosh apple trees located at the New York State Agricultural Experiment Station (Geneva, NY). Five flower clusters (one per timing treatment) were caged on each of ten trees of each variety, and all but the three oldest (according to size and degree of openness) flowers or fruitlets were removed. Cages were infested with two to three bugs (depending on the number collected at each treatment period) at bloom, petal fall (PF), fruit set (fruit at 6 mm: PF + 6 d, McIntosh; PF + 7d, Red Delicious) or fruit set + 7 d (fruit at 13 mm). Treatments were completely randomized and sample size varied from 9 to 15 fruit per treatment because of losses of fruit during the growth period and availability of nymphs. The check was a sample of 741 Red Delicious and 500 McIntosh uncaged fruits chosen by

Table 1. Mean percentage of mullein bug and apple brown bug fruit damage after insecticide treatment at different stages, Red Delicious, June 1996 and 1998

Treatment	% fruit in each damage category[a]					
	% Drop	Clean	Fancy[b]	No. 1	Cull	No. 1 + Cull
1996, fruit remaining on tree						
Esfenvalerate at bloom	58.4a	–	97.2a	2.0a	0.8a	2.8a
Esfenvalerate at PF	60.6a	–	83.7b	13.9b	2.4a	16.3b
Esfenvalerate at 10-mm fruit	85.5b	–	81.3b	8.6ab	10.1a	18.7b
Check	89.8b	–	83.2b	10.6b	6.2a	16.8ab
1998, fruit remaining on tree						
Esfenvalerate at bloom	22.4a	90.3a	9.2a	0.0a	0.6a	0.6a
Esfenvalerate at PF	41.5b	86.5a	6.7ab	4.8ab	1.9a	6.8ab
Esfenvalerate at 10-mm fruit	41.8b	71.9a	12.8b	3.5ab	11.8a	15.3b
Check	55.8c	54.6b	3.9ab	12.2b	29.3b	41.5c
1998, drops						
Esfenvalerate at bloom	–	100.0a	0.0a	0.0a	0.0a	0.0a
Esfenvalerate at PF	–	86.3a	6.1a	1.1a	6.6ab	7.6ab
Esfenvalerate at 10-mm fruit	–	76.7a	9.1b	3.7ab	10.6b	14.3b
Check	–	48.9b	1.9a	11.6b	37.5c	49.1c

[a] For each year and fruit grouping, means within a column followed by the same letters are not significantly different ($P < 0.05$; Fisher's Protected LSD test).
[b] Includes clean fruit, 1996.

randomly picking up to 20 of the remaining fruits on each tree that was used for the timing treatments within the same blocks as the caged fruit.

In 2000, flower clusters on trees in a research orchard in Geneva, NY, were caged and infested as in 1999. However, instead of using uncaged fruits from the entire orchard to determine a background level of damage, a check treatment was included in which flower clusters were caged, but no nymphs were introduced. Also, because some background damage to Red Delicious had occurred in the same orchard in 1999, we caged all treatments before bloom to exclude nymphs hatching elsewhere in the tree, then artificially pollinated caged flowers using commercially produced pollen (Antles Pollen Supplies, Wenatchee, WA) applied at full bloom with the fingertip. Fruit clusters were infested at bloom, petal fall, fruit set (McIntosh, PF + 6 d, fruit at 6–10 mm; Red Delicious, PF + 9d, fruit at 6 mm), fruit set +7 d (fruit at 13 mm, both cultivars), fruit set +17 d (fruit at 19 mm, Red Delicious) or fruit set + 19 d (fruit at 19 mm, McIntosh) with nymphs hatched in a growth chamber, as in 1999. To determine the effect of nymphal stage on damage, Red Delicious fruit clusters were infested with two to three small (first–third instar) nymphs versus two to three large (fourth and fifth instar) nymphs at fruit set (small nymphs on 22 May, fruit 6 mm, large nymphs on 24 May, fruit 6 mm), fruit set + 7 d (30 May, fruit 13 mm), and fruit set + 17 d (9 June, fruit 19 mm). McIntosh fruitlets received an additional treatment with large nymphs only at the fruit set + 19 d timing (6 June). Damage timing data from 1999 and 2000 were analyzed using a generalized estimating equation model with a binary distribution and logit link with an exchangeable covariance, because observations were nested within trees; the response variable used was presence of damage. Significant main effects of treatment were followed by posthoc multiple comparison tests with Tukey–Kramer adjustments (Proc GENMOD, SAS Institute 2010). Some estimators were slightly amended to accommodate cell counts of zero (Agresti 2007).

Varietal Susceptibility to *C. verbasci* Oviposition, 2000. Forty cuttings (four limbs from 10 trees) of ≈1-m-long, 2-yr-old limbs were taken from a number of orchards of "susceptible" cultivars (Red Delicious, Northern Spy, Mutsu) in late winter, as well as from adjacent McIntosh orchards in Wayne and Ontario counties. Mirid eggs that had been laid in the limb cuttings were forced to hatch in a growth chamber (25°C, 60% RH, and a photoperiod of 16:8 [L:D] h) so that we could observe whether nymph population levels in McIntosh were similar to those in the "susceptible" varieties. Differences in the mean number of nymphs per 40 cuttings between the two groups (susceptible varieties versus McIntosh) was determined using Student's *t*-test ($P = 0.05$).

Results and Discussion

Timing of Fruit Damage by Naturally Occurring Nymphs, 1996. In the June drop rating, significantly less fruit drop occurred when esfenvalerate was applied at bloom or petal fall than when it was applied at 10-mm fruit size (8 d after petal fall) or not at all [Table 1; df, F, and P values in damage categories: Fancy, 57(3,54), 2.910, 0.0427; #1, 57(3,54), 3.586, 0.0194; Cull, 57(3,54), 1.329, 0.2745; #1+Cull, 57(3,54), 2.909, 0.0428; % drops, 63(3,60), 5.679, 0.0017]. This may have been partly because of protection from the thinning chemical by the cages in the first two treatments. However, uncaged branches on these trees did not appear to be excessively thinned, and many of the dropped fruit observed in these two treatments were severely damaged by mirids. Therefore, it appears that more fruit drop occurred where mirid nymphs were not controlled until after petal fall. Of the fruit remaining on the tree, there were significantly more fruit in the Fancy category (which included clean fruit) in the plots sprayed at bloom.

Table 2. Relationship between time of mullein bug nymph infestation and mean percentage of fruit damaged, 1999–2000

Growth stage when infested	Nymph size[a]	Proportion of clusters with damage[b]	n[c]	z Value	Pr > z
1999, Red Delicious					
Petal fall	–	0.43a	15	0.68	0.4956
Bloom	–	0.44ab	9	-0.17	0.8684
Fruit set	–	0.0ab	16	-1.89	0.0592
Fruit set + 7 d	–	0.0ab	13	-2.09	0.0370
Check	–	0.13b	741	-4.00	<0.0001
2000, Red Delicious					
Bloom	Small	0.89a	38	2.89	0.0039
Petal fall	Small	0.61ab	43	0.90	0.3655
Fruit at 10 mm	Small	0.12bc	30	-2.63	0.0085
Fruit at 10 mm	Large	0.25bc	29	-2.08	0.0375
Fruit at 10 mm + 7d	Small	0.06bc	32	-2.68	0.0073
Fruit at 10 mm + 7d	Large	0.21bc	24	-2.35	0.0188
Fruit at 10 mm + 17d	Small	0.0c	11	-1.96	0.0501
Fruit at 10 mm + 17d	Large	0.0c	10	-1.99	0.0463
Check	–	0.05c	44	-2.87	0.0041
2000, McIntosh					
Bloom	Small	0.87a	25	2.44	0.0148
Petal fall	Small	0.67ab	44	1.36	0.1730
Fruit at 10 mm	Small	0.06bc	32	-2.80	0.0050
Fruit at 10 mm + 7d	Small	0.07c	25	-2.72	0.0066
Fruit at 10 mm + 19d	Small	0.0c	8	-1.57	0.1161
Fruit at 10 mm + 19d	Large	0.0c	16	-2.14	0.0327
Check	–	0.11c	50	-2.88	0.0040

[a] Small, first–third instar; large, fourth–fifth instar.
[b] For each year and cultivar, means within a column followed by the same letters are not significantly different ($P = 0.05$; Tukey–Kramer, SAS Institute 2010).
[c] Number of fruitlets.

There was also significantly less fruit downgraded (#1 + Cull) in the bloom treatment than in the petal fall or 10 mm fruit treatments, but not significantly less than in the check.

1998. Similar to 1996, significantly more fruit dropped when esfenvalerate was applied after the bloom–petal fall period. In 1998, damage to dropped fruit was evaluated. Significantly more dropped fruit were severely damaged in the check treatment, indicating that mirid injury may have contributed to increased fruit drop [Table 1; fruit remaining on the tree: df, 60(3,57); F, and P values in damage categories: Clean, 5.365, 0.0025; Fancy, 0.709, 0.5504; #1, 2.198, 0.0982; Cull, 8.817, <0.0001; #1+cull, 10.307, <0.0001. For dropped fruit: df, 57(3,54); F, and P values in damage categories: Clean, 6.921, 0.0005; Fancy, 3.577, 0.0197; #1, 2.363, 0.0813; Cull, 7.218, 0.0004; #1+cull, 10.247, <0.0001].

Results in 1998 indicate, again, that most fruit damage occurs between the time of bloom and petal fall. A difference in the percentage of fruit downgraded between the 10 mm fruit treatment and the check in 1998 indicates that damage can still occur up until fruit are ≈10 mm, or later. We would expect that, if damage no longer occurred after petal fall, fruit damage levels in these two treatments would not be different. Small nymphs were present for a longer time after petal fall in 1998 than we had previously observed. Because we did not include a treatment later than 10 mm fruit, it is not possible to say whether damage occurred after that period.

The 1996 and 1998 spray timing experiments demonstrate that much of the damage caused to Red De-

licious by mirids occurs before petal fall, and that application of an effective insecticide before petal fall will prevent damage better than a postbloom application. However, these trials do not indicate when the damage might cease to occur in the absence of control measures, that is, the time when an insecticide application is no longer necessary.

Damage by Introduced Nymphs, 1999. Reding et al. (2001) hypothesized that crop susceptibility to *C. verbasci* damage is because of synchrony between pest and crop phenology, a hypothesis we tested in our 1999 trials. Our times of infestation simulated times that peak egg hatch might occur, and nymphs were allowed to complete development. Therefore, the precise time that fruit damage occurred was not determined, but the damage we recorded is related to a particular time of egg hatch. In western New York, this typically takes place about the time of Red Delicious full bloom. Table 2 shows that damage to Red Delicious in 1999 occurred only when nymphs were present at petal fall or earlier.

Damage to McIntosh occurred in plots infested between bloom and petal fall, but not in those infested at 10-mm fruit or 1 wk later. Damage to this variety was minimal in any treatment, however, and there were too few positive observations (a total of only two damaged fruits) to analyze the data. But these results support the assertion of Boivin and Stewart (1982), who caged a number of different species of phytophagous mirids on McIntosh to determine the effects of their feeding on fruit. In their studies, *C. verbasci* nymphs were not placed in cages until fruit were ≈10 mm and, although feeding punctures were noted, no

Table 3. Number of mullein bug nymphs forced to hatch from cuttings taken from "susceptible" varieties and adjacent McIntosh orchards, 2000

Orchard	Nymphs/40 cuttings	
	Susceptible	McIntosh
Red Delicious 1	12	4
Mutsu	35	1
Red Delicious 2	17	9
Northern Spy	17	8
Red Delicious 3	35	5
Red Delicious 4	31	0
Red Delicious 5	12	1
Mean	22.7	4.0
Std. dev.	10.5	3.6

$t_{0.05} = 2.365$, $P = 0.003$, $n = 7$.

damage was evident at harvest. They concluded that fruit were "too well formed to be mechanically damaged" at that time.

2000. Damage to both Red Delicious and McIntosh was significantly greater in plots infested between bloom and petal fall than in untreated plots, and greater in plots infested at bloom than those infested at 10 mm fruit or 1 wk after 10 mm fruit (Table 2). No damage occurred in plots infested 17 d (Red Delicious) or 19 d (McIntosh) after 10 mm fruit. There was a population of *A. mali* nymphs present during bloom in the McIntosh planting, which may account for a higher than expected level of damage in the check treatment in that orchard (Table 2).

These data support the conclusion by Reding et al. (2001) that most damage is a result of nymphs feeding between the bloom and petal fall stages, and that after fruit are ≈10 mm they are much less sensitive to damage, and suggest that after fruit reached 19 mm, they are no longer susceptible to damage.

Varietal Susceptibility to *C. verbasci* Oviposition. *C. verbasci* adults appear to have laid more eggs on "susceptible" varieties than on McIntosh in 2000, according to the significant difference in nymphs found between these two groups. (Table 3)

Although some varieties such as McIntosh may harbor fewer overwintering eggs to begin with, we suggest that damage to fruit is a function of crop susceptibility during a particular phenological stage and that some varieties usually have developed beyond that susceptible stage by the time that nymphs are present. Damage resulting from caging *C. verbasci* nymphs on McIntosh flowers in our studies indicates that this cultivar certainly is attacked and is sensitive to feeding injury if infested from bloom through petal fall. However, we did not assess fruit damage at harvest. Thistlewood et al. (1989) observed that damage was evident in June drop samples of McIntosh. Although there was significantly less damage to that cultivar than to Red Delicious or Golden Delicious, on average, they saw no differences among varieties within most of the orchards they sampled. Subsequently, they noted significant differences in injury between Red Delicious and Golden Delicious versus McIntosh in samples taken at harvest, suggesting that McIntosh is less sus-

ceptible because of a differential reaction to injury (i.e., fruit drop).

In some seasons, although they are abundant, *C. verbasci* nymphs cause little or no damage, even to cultivars known to be susceptible. In insecticide efficacy trials in 1997, for example (D.P.K., unpublished data), no damage to fruit occurred in any of our plots (Red Delicious and Golden Delicious), even though high numbers of mirid nymphs were present in a number of them. One explanation for the lack of fruit damage may be that when the prey of phytophagous mirids such as European red mite and aphids are abundant, the mirids feed preferentially on them and less on the plant. However, Thistlewood et al. (1989) reported "damage was observed with and without . . . alternate prey during bloom." Bartlett (1996) found that, even with prey available, *C. verbasci* nymphs fed on plant parts, and Reding et al. (2001) found no difference in the level of damage when prey were made available to caged *C. verbasci* nymphs, than the level of damage when no prey were available. Although G. Chouinard and S. Gagnon (personal communication) did find that the presence of European red mites influenced the amount of damage caused by *C. verbasci* nymphs, they nevertheless observed damage to fruit whether or not the prey were present. Another explanation for the lack of damage may be that when there is a delay in *C. verbasci* egg hatch, most nymphs are not present until a time when floral structures are no longer available, or fruit are less susceptible to damage. Conversely, when climatic conditions are such that nymphs are present while the crop is susceptible, even varieties thought not to be susceptible may be damaged. We have shown that if McIntosh flowers or fruitlets are infested during the bloom–petal fall period, then the cultivar is susceptible. Québec researchers observed considerable damage to McIntosh during a comparatively warm, early spring (1999) that resulted in an earlier than normal *C. verbasci* hatch, which occurred during the McIntosh bloom period (G. Chouinard, personal communication). We observed the same situation during that season in Wayne Co., NY. Therefore, we suggest that McIntosh may be less susceptible to damage by *C. verbasci*, and possibly other phytophagous mirids such as *A. mali*, because of asynchrony between the bloom period of this cultivar and hatch of the overwintered eggs of the bugs. The hypothesis that no damage would occur when host bloom and pest egg hatch phenology are asynchronous would explain why, in some years, even "susceptible" varieties are not injured even though the bugs are present.

In some apple-growing areas where *C. verbasci* is a pest, control is recommended if first generation nymphs are above a local action threshold at any time, starting at bloom and continuing for 2–3 wk after petal fall (Reding and Beers 1996, Solymar 1999). Our studies agree with those of Reding et al. (2001), suggesting that insecticides aimed specifically at *C. verbasci* nymphs present after fruit are ≈13 mm (2 wk after petal fall in our studies) are unnecessary for preventing fruit damage, and may instead diminish biological

control of prey such as European red mite and aphids. Insecticides will be most effective in preventing damage if applied before petal fall.

If fruit susceptibility is a matter of crop development in relation to pest development, this information would be useful in indicating which varieties will be at risk in a given season. We would hypothesize that any cultivar, if attacked during the full bloom to petal fall stage of development, will incur fruit damage and that likewise, if *C. verbasci* egg hatch does not occur until after fruit are ≈10–13 mm, fruit will not be damaged. If this is correct, a method of predicting whether or not overwintered *C. verbasci* eggs will hatch during the crop's susceptible period would allow an accurate determination of the need for sprays applied at the pink stage.

Acknowledgments

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