Techniques for Monitoring Cranberry Tipworm (Diptera: Cecidomyiidae) in Rabbiteye and Southern Highbush Blueberries

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ABSTRACT Several monitoring techniques were evaluated for their effectiveness, based on the highest mean captures of cranberry tipworm, *Dasineura oxycoccana* (Johnson), in detecting *D. oxycoccana* in rabbiteye, *Vaccinium ashei* Reade, and southern highbush, *V. corymbosum* L. × *V. darrowi* Camp, blueberry plantings. There were no significant differences in captures of *D. oxycoccana* adults on unbaited sticky board traps, regardless of color (yellow, white, green, or blue). In a separate experiment, three monitoring techniques, yellow unbaited sticky boards, larval/adult emergence from infested buds, and bud dissection, were evaluated for detecting *D. oxycoccana*, eggs, larvae, and adults. In total, four bud types were examined, including rabbiteye floral, rabbiteye leaf, southern highbush floral, and southern highbush leaf. The emergence monitoring technique detected significantly more *D. oxycoccana* adults than the other techniques evaluated. Emergence and dissection techniques performed equally well for detecting *D. oxycoccana* larvae. Dissection was the only technique capable of detecting *D. oxycoccana* eggs. Overall, the highest numbers of *D. oxycoccana* eggs were detected in southern highbush leaf buds. However, larval infestation was lower for southern highbush leaf buds compared with other bud types sampled. Hypotheses to explain this phenomenon are discussed. The fewest number of eggs was recorded for southern highbush flower buds, potentially because these buds develop before peak emergence of *D. oxycoccana*. Managing *D. oxycoccana* in infested plantings can be improved by incorporating monitoring techniques, specifically bud dissection to search for eggs, that will aid growers in making timely insecticide applications.

KEY WORDS *Dasineura oxycoccana*, *Vaccinium* spp., traps, monitoring

THE CRANBERRY TIPWORM, *Dasineura oxycoccana* (Johnson), is a recently discovered pest of rabbiteye, *Vaccinium ashei* Reade, and southern highbush, *Vaccinium corymbosum* L. × *V. darrowi* Camp, blueberries in the southeastern United States (Lyrene and Payne 1992). Female flies oviposit eggs into susceptible floral and leaf buds, and during heavy infestations, more than one female may oviposit into a single bud (Bosio et al. 1998). Larvae feed on plant juices, which ultimately kills developing buds (Mahr and Kachadoorian 1990). Unmanaged *D. oxycoccana* infestations can destroy up to 80% of floral buds in susceptible rabbiteye cultivars (Lyrene and Payne 1992, 1995).

Until recently, the presence of *D. oxycoccana* in Florida blueberry plantings was misdiagnosed as freeze damage (Lyrene and Payne 1995). This discrepancy has complicated accurate assessment of floral and vegetative bud loss in blueberry plantings throughout Florida and much of the southeastern United States. Lyrene and Payne (1992) were the first to identify *D. oxycoccana* affecting floral buds within rabbiteye blueberries. Infestations have since been identified in blueberry plantings in Italy and other European countries (Bosio et al. 1998).

Currently, the Florida blueberry industry is undergoing a conversion from long-established rabbiteye cultivars to southern highbush cultivars, with acreage of southern highbush increasing 23% from 1989 to 2000 (Williamson et al. 2000). The trend toward commercial production of southern highbush plantings in Florida is a response to an increased market for early-season blueberries, which have a higher market value than later ripening blueberries from primary blueberry-producing states (Williamson et al. 2000). Despite this trend, blueberry production in Florida may become limited by an expected increase in insect problems (Mizell and Johnson 2001). In a recent crop profile for blueberries in the southeastern United States, *D. oxycoccana* was listed as a major pest warranting attention, particularly with regard to monitoring strategies and evaluation of alternative chemical management protocols (NeSmith 1999).

According to Gagné (1989), adult *D. oxycoccana* live only long enough to mate and lay eggs, ≈2 to 3 d. Cranberry tipworm is known to have overlapping generations throughout its described range, which in-

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cludes the southeast as well as cranberry- and blueberry-producing areas in the north (Liburd and Finn 2002). Mahr and Kachadoorian (1990) reported that *D. oxycoccana* completed up to five generations in Wisconsin cranberry bogs, although later work by Cockfield and Mahr (1994) suggested that distinct broods are not easy to distinguish. In Mississippi, *D. oxycoccana* are capable of completing up to 11 generations per year (Sampson et al. 2002).

Reliable techniques to monitor and quantify populations of *D. oxycoccana* in blueberry plantings have not been thoroughly evaluated. Currently, yellow sticky boards are used within some plantings to monitor the presence of adult midges and the abundance of their natural enemies (Bosio et al. 1998; B. J. Sampson, USDA, Poplarville, MS, personal communication). Other colors of sticky boards have not been evaluated in the United States, despite knowledge that dipterans can be monitored effectively using various colored traps (Vernon and Broatch 1996, Liburd et al. 1998). Other frugivorous insects such as flower thrips, *Frankliniella* spp. (Thysanoptera: Thripidae), respond to blue and white (Cho et al. 1995, Childers and Brecht 1996). Because flower thrips are another key pest in Florida blueberry plantings, and because they affect blueberry production during approximately the same time interval as *D. oxycoccana* (unpublished data), the development of a trapping technique that may simultaneously monitor the presence of both pests is desirable.

Our objectives were to determine whether color influences captures of *D. oxycoccana* adults on unbaited sticky traps in the field and to evaluate several sampling techniques for detecting various life stages of *D. oxycoccana.* Finally, we compared rabbiteye and southern highbush floral and leaf buds for the presence of *D. oxycoccana* eggs and larvae.

Materials and Methods

All experiments were conducted in 2-ha blocks of rabbiteye and southern highbush plantings in north central Florida. Bushes in the rabbiteye planting were unmanaged for at least 3 yr before the start of studies and were ≈2–3 m in height in 2002 and ≈1.5–2 m in height in 2003 (after pruning in July 2002). The planting was located in Windsor, FL, and consisted of 'Beckyblue,' 'Bonita,' and 'Climax'. Bush spacing was 1.5 m apart and 2.4 m between rows. Bushes in the southern highbush plantings were managed commercially and were ≈1.5–2 m in height at each of the two sites. One southern highbush planting was located in Inverness, FL, and contained 'Misty,' 'Jewel,' and 'Sharpblue'. Bush spacing was 1.5 m apart and 2.4 m between rows. A second southern highbush planting was located in Windsor, FL, within 500 m of a rabbiteye planting. Bushes in the second southern highbush planting were multiple clone types (no cultivar identification) and spaced 1.5 m apart with 1.5 m between rows (high-density bed).

Unbaited Colored Traps. Experiments to evaluate the effect of color for monitoring *D. oxycoccana* adults by using unbaited sticky traps were conducted in rabbiteye and southern highbush plantings in Windsor and Inverness, FL, respectively. In 2002, *D. oxycoccana* adults were monitored once per week for a 6-wk period, from 5 March to 12 April, at the rabbiteye planting and from 31 January to 6 March at the southern highbush planting. In 2003, monitoring was conducted only in the rabbiteye planting because data from the previous year indicated that *D. oxycoccana* populations were too low in the southern highbush planting to warrant sampling again. Monitoring was conducted twice per week from 6 to 21 March (five sampling dates in total). The monitoring period for each planting included the seven stages of floral bud development as outlined by Spiers (1978).

Various colors of commercially produced rectangular unbaited sticky board traps (treated area 394 cm^2; Great Lakes IPM, Vestaburg, MI) were used to monitor *D. oxycoccana* adults in commercial blueberry plantings. Four trap colors were evaluated: 1) standard Pantone yellow, 2) safety white, 3) walnut husk green, and 4) thrips blue. Experimental design was randomized complete block with four replicates per treatment in each planting. Traps were hung within the canopy of bushes in a vertical position and spaced 10 m apart and 15 m between blocks. Traps were rerandomized and replaced once per week in 2002 and twice per week in 2003. Traps that were removed from the field were covered with a layer of plastic wrap and transported back to the laboratory for a two-stage visual analysis.

In the initial analysis, traps were screened for *D. oxycoccana* adults by using a benchtop-illuminated magnifier (three-dimensional, Cole-Palmer Instrument Co., Vernon Hills, IL). All specimens with morphological characteristics resembling *D. oxycoccana* were encircled on the plastic and subjected to a second analysis. Positive identification of *D. oxycoccana* was conducted using a 10× dissecting microscope. Raymond Gagné (USDA–ARS, Beltsville, MD) and Blair Sampson (USDA–ARS, Poplarville, MS) confirmed the identification of specimens. The most effective trap color was determined based on the highest mean captures of *D. oxycoccana* adults throughout the season.

Monitoring Techniques. Experiments to evaluate techniques for detecting various life stages of *D. oxycoccana* were conducted in both rabbiteye and southern highbush plantings in Windsor, FL. Three techniques were evaluated for their effectiveness in detecting and quantifying *D. oxycoccana:* 1) use of unbaited yellow sticky boards, 2) collection of bud samples for larval/adult emergence, and 3) collection of bud samples for dissection. All three sampling techniques have been used previously to detect or quantify densities of pests within a system. In techniques 2 and 3, 140 floral buds and 140 vegetative buds were collected for analysis on each sampling date from each planting. Experimental design was randomized complete block with four replicates per treatment in each planting. Treatments were blocked by cultivar in the rabbiteye planting and by clone in the southern high-

Table 1. Comparison of techniques for monitoring *D. oxycoccana* in rabbiteye blueberries in Windsor, FL (2002)

	Mean ± SEM *D. oxycoccana*					
	Floral buds			Leaf buds		
	Adult	Larva	Egg	Adult	Larva	Egg
Sampling technique						
Yellow sticky boards[a]	4.0 ± 2.0b	1.3 ± 0.8b		4.0 ± 2.0	1.3 ± 0.8b	
Emergence	72.8 ± 12.2a	104.3 ± 17.5a		2.3 ± 1.3	3.5 ± 1.9ab	
Dissection	0.0 ± 0.0b	135.5 ± 32.4a	17.3 ± 6.3	0.0 ± 0.0	12.0 ± 6.4a	13.3 ± 2.0

Means within columns followed by the same letter are not significantly different, $P > 0.05$, LSD test. Analyses were performed on square-root transformed data, but means shown reflect untransformed data.

[a] Data for yellow sticky boards were identical for floral and leaf bud comparisons because sampling was conducted on the same dates for these bud types.

bush planting. Experimental plots consisted of 15 bushes and were designated according to treatment.

In both rabbiteye and southern highbush plantings, buds were collected when floral and leaf buds were presumed to be most susceptible to *D. oxycoccana* infestation, i.e., stages 2–4 of floral bud development (Spiers 1978) and stages 2–4 of leaf bud development (NeSmith et al. 1998). In rabbiteye plantings, floral bud and leaf bud development usually occur simultaneously. Therefore, in 2002 sampling for both bud types was conducted on 8, 15, and 19 March, and in 2003, sampling was conducted on 3, 6, and 10 March. In southern highbush plantings, stages 2–4 of floral bud development usually precedes vegetative bud development by ≈3 wk. In 2002, floral buds were collected from the southern highbush planting on 7, 11, and 18 February, and leaf buds were collected on 5, 11, and 18 March. In 2003, floral buds were collected on 3, 7, and 13 February, and leaf buds were collected on 24 February and 3 and 6 March.

Monitoring boards were sampled using the two-stage visual analysis described in the section for our colored board experiment. Briefly, traps were screened for the presence of flies resembling *D. oxycoccana*, and then highlighted specimens were observed under a 10× dissecting microscope to make an accurate identification. One hundred forty buds per treatment (35 buds from each replicate) were collected at random for larval emergence and dissection techniques. Floral and vegetative buds were collected separately and placed into resealable transparent containers for transportation back to the laboratory. Buds collected for monitoring larval emergence were transferred to 15-cm plastic petri dishes containing moistened filter paper and held at 27°C under a photoperiod of 14:10 (L:D) h for 10 d. The total number of emergent larvae and adults was recorded. Buds ($n = 140$) collected for dissection were dissected under a 10× dissecting microscope and all life stages of *D. oxycoccana* found were recorded. Treatments were rotated among experimental plots on a weekly basis. The most efficient sampling technique was determined based on the abundance of various life stages of *D. oxycoccana.*

Bud Type Comparison. Data collected from the dissection technique were used to compare infestation rates of floral buds and leaf buds collected from both rabbiteye and southern highbush plantings. Due to variations in plant phenology, the four bud types (rabbiteye floral, rabbiteye leaf, southern highbush floral, and southern highbush leaf) were collected over different time periods. Nonetheless, overall comparisons were made to determine which buds were most susceptible to *D. oxycoccana* infestation. In 2002 and 2003, bud types were compared for the presence of eggs and larvae. In addition, larvae were also categorized by instar in 2003.

Data Analysis. Data from all three studies were square-root transformed to account for deviations from normality and then subjected to an analysis of variance (ANOVA) followed by mean separation with least significant difference (LSD) tests (SAS Institute 2001). Data also were subjected to repeated measures analysis (PROC MIXED, SAS Institute 2001) to examine the interaction effect between treatment and time (sampling dates) throughout the duration of each experiment. When significant interaction effects were noted, further analysis was conducted to determine the order of treatment efficacy for each sampling date. Means were considered significantly different when P values were ≤ 0.05. The untransformed means and standard errors are presented in tables.

Results

Unbaited Colored Traps. In 2002, there were no significant differences in captures of *D. oxycoccana* adults on unbaited sticky boards of various colors in either the rabbiteye ($F = 2.2$; df = 3, 9; $P = 0.16$) or the southern highbush ($F = 2.2$; df = 3, 9; $P = 0.16$) plantings. Overall, the number of *D. oxycoccana* adults caught on traps averaged less than one fly per trap during each sampling date in 2002. In 2003, trap captures were higher, averaging eight to nine flies per trap during each sampling date. Still, we found no differences in captures of adults on the various colors of traps ($F = 3.0$; df = 3, 9; $P = 0.09$).

Monitoring Techniques. In 2002, the emergence technique was significantly more effective in detecting *D. oxycoccana* adults in rabbiteye floral buds compared with unbaited yellow sticky boards or dissection techniques ($F = 53.5$; df = 2, 6; $P < 0.01$) (Table 1). Emergence and dissection techniques performed equally well for detecting *D. oxycoccana* larvae in rabbiteye floral buds, and both techniques detected significantly more larvae compared with unbaited yellow sticky boards ($F = 57.1$; df = 2, 6; $P < 0.01$) (Table

Table 2. Comparison of techniques for monitoring *D. oxycoccana* in southern highbush blueberries in Windsor, FL (2002)

	Mean ± SEM *D. oxycoccana*					
	Floral buds			Leaf buds		
	Adult	Larva	Egg	Adult	Larva	Egg
Sampling technique						
Yellow sticky boards	1.0 ± 0.7	0.0 ± 0.0b		0.8 ± 0.5	0.0 ± 0.0b	
Emergence	1.4 ± 0.9	2.0 ± 1.2b		0.5 ± 0.3	0.8 ± 0.5ab	
Dissection	0.0 ± 0.0	16.8 ± 4.7a	7.3 ± 4.6	0.0 ± 0.0	5.0 ± 2.6a	56.0 ± 11.3

Means within columns followed by the same letter are not significantly different, $P > 0.05$, LSD test. Analyses were performed on square-root transformed data, but means shown reflect untransformed data.

1). There were no significant differences among sampling techniques for detecting adults in rabbiteye leaf buds ($F = 2.3$; df = 2, 6; $P = 0.18$) (Table 1). Among all of the plant material we analyzed, the only sampling technique capable of detecting *D. oxycoccana* eggs was dissection (Tables 1–4).

The number of *D. oxycoccana* adults detected using our three techniques did not differ in southern highbush floral buds ($F = 1.8$; df = 2, 6; $P = 0.25$) and leaf ($F = 1.2$; df = 2, 6; $P = 0.36$) (Table 2). However, the dissection technique was significantly more effective in detecting *D. oxycoccana* larvae in southern highbush floral buds compared with the emergence technique or unbaited yellow sticky boards ($F = 38.0$; df = 2, 6; $P < 0.01$) (Table 2). Six times more *D. oxycoccana* larvae were detected in leaf buds by dissection than by emergence techniques (Table 2).

In 2003, infestation of flower buds by *D. oxycoccana* in the rabbiteye planting was slightly higher in 2003 than in 2002. As in 2002, the emergence technique was significantly more effective in detecting *D. oxycoccana* adults in floral buds compared with either yellow boards or dissection ($F = 101.0$; df = 2, 6; $P < 0.01$) (Table 3). However, in our analysis of leaf buds, yellow sticky boards were significantly more effective in detecting adults compared with emergence or dissection techniques ($F = 28.2$; df = 2, 6; $P < 0.01$) (Table 3). Importantly, there were significant interaction effects between treatment and time (sampling dates) for the detection of *D. oxycoccana* adults in rabbiteye floral buds ($F = 8.6$; df = 6, 18; $P < 0.01$). That is, treatment efficacy varied over the three sampling dates. Specifically, yellow sticky boards were not effective for detecting *D. oxycoccana* adults early in the season (3 and 7 March) but were significantly more effective than dissection techniques later in the season (10 March) ($F = 47.9$; df = 2, 6; $P < 0.01$). Again, significant interaction effects between treatment and sampling dates were observed for rabbiteye leaf buds, whereas yellow sticky boards were not effective for detecting adults on 3 March, but they were more effective than dissection and emergence techniques on 6 and 10 March ($F = 6.6$; df = 6, 18; $P < 0.01$).

Similar numbers of *D. oxycoccana* larvae were detected using emergence and dissection techniques in rabbiteye floral and leaf buds (Table 3). As in 2002, some larvae were detected on sticky boards, although their incidence was sporadic.

In the southern highbush planting, the emergence technique was significantly more effective in detecting *D. oxycoccana* adults in floral and leaf buds compared with yellow sticky boards or dissection ($F = 169.8$; df = 2, 6; $P < 0.01$) (Table 4). Similarly, our emergence technique was significantly more effective in detecting *D. oxycoccana* larvae in southern highbush floral buds compared with the dissection technique ($F = 31.4$; df = 2, 6; $P < 0.01$) (Table 4). However, sampling techniques did not differ for detecting larvae in southern highbush leaf buds ($F = 3.8$; df = 2, 6; $P = 0.09$). In 2003, we did not record any *D. oxycoccana* eggs in southern highbush floral buds. However, a substantial number of *D. oxycoccana* eggs were detected in southern highbush leaf buds.

On several occasions, we noted the presence of adult parasitic wasps (Hymenoptera: Platygastridae) in buds collected for our emergence and dissection treatments. However, we never witnessed the emergence of this wasp from *D. oxycoccana* larvae. In addition, *D. oxycoccana* adults reared in the laboratory for this study indicated a sex ratio of ≈60–70% females.

Table 3. Comparison of techniques for monitoring *D. oxycoccana* in rabbiteye blueberries in Windsor, FL (2003)

	Mean ± SEM *D. oxycoccana*					
	Floral buds			Leaf buds		
	Adult	Larva	Egg	Adult	Larva	Egg
Sampling technique						
Yellow sticky boards[a]	12.8 ± 3.4b	0.3 ± 0.3b		12.8 ± 3.4a	0.3 ± 0.3b	
Emergence	122.5 ± 13.0a	175.0 ± 18.7a		4.3 ± 1.7b	6.0 ± 2.1a	
Dissection	0.0 ± 0.0c	182.3 ± 15.5a	27.5 ± 7.9	0.0 ± 0.0c	4.0 ± 2.0ab	31.3 ± 8.2

Means within columns followed by the same letter are not significantly different, $P > 0.05$, LSD test. Analyses were performed on square-root transformed data, but means shown reflect untransformed data.

[a] Data for yellow sticky boards were identical for floral and leaf bud comparisons since sampling was conducted on the same dates for these bud types.

Table 4. Comparison of techniques for monitoring *D. oxycoccana* in southern highbush blueberries in Windsor, FL (2003)

	Mean ± SEM *D. oxycoccana*					
	Floral buds			Leaf buds		
	Adult	Larva	Egg	Adult	Larva	Egg
Sampling technique						
Yellow sticky boards	0.3 ± 0.3b	0.0 ± 0.0c		0.3 ± 0.3b	0.0 ± 0.0	
Emergence	19.8 ± 3.5a	28.0 ± 5.1a		4.0 ± 2.7a	5.8 ± 3.8	
Dissection	0.0 ± 0.0b	13.8 ± 4.4b	0.0 ± 0.0	0.0 ± 0.0b	6.3 ± 3.6	52.5 ± 15.5

Means within columns followed by the same letter are not significantly different, $P > 0.05$, LSD test. Analyses were performed on square-root transformed data, but means shown reflect untransformed data.

Bud Type Comparison. In 2002, there were significantly more *D. oxycoccana* eggs in southern highbush leaf buds compared with any other bud types ($F = 9.9$; df = 3, 9; $P < 0.01$) (Table 5). Eggs were found least often in southern highbush floral buds in both 2002 and 2003. The number of eggs in southern highbush floral buds was similar to that of rabbiteye floral and leaf buds in 2002. Similar numbers of *D. oxycoccana* eggs were recorded in rabbiteye floral and leaf buds in both years (Tables 5 and 6). We recorded significantly more *D. oxycoccana* larvae in rabbiteye floral buds compared with any other bud type in 2002 ($F = 39.7$; df = 3, 9; $P < 0.01$).

In 2003, the highest number of *D. oxycoccana* eggs was recorded in southern highbush leaf buds (Table 6). Significantly more first instars were detected in rabbiteye floral buds compared with any other bud types ($F = 18.2$; df = 3, 9; $P < 0.01$), followed by southern highbush floral buds, which had significantly more first instars than leaf buds of southern highbush plants ($F = 18.2$; df = 3, 9; $P < 0.01$) (Table 6). Second instars were significantly more abundant in rabbiteye floral buds compared with any other bud types ($F = 485.0$; df = 3, 9; $P < 0.01$) (Table 6). Similar results were recorded for third instars.

Discussion

Our studies indicate that *D. oxycoccana* adults do not respond differentially to the various colors of unbaited sticky board traps we evaluated. Currently, unbaited sticky traps seem to be an ineffective tactic for monitoring *D. oxycoccana* populations. However, the use of sticky traps for monitoring *D. oxycoccana* adults may be improved by incorporating a luring device, either a sex pheromone or a host-volatile compound, or by changing trap height or type. A better understanding of olfactory stimuli and responses in *D. oxycoccana* may compliment the use of visual stimuli in future monitoring efforts. The relative increase in mean trap counts from 2002 to 2003 was likely due to higher pressure of *D. oxycoccana* in the field and also to the better condition of board-preserved specimens, which was facilitated by replacing traps more frequently. Overall, identification of *D. oxycoccana* was difficult due to several key factors: small size (≈2 mm), the sticky surface of the traps, specimen degradation in the field, poor preservation of distinguishing characteristics, and the presence of other flies within the family Cecidomyiidae. The sticky surface on the monitoring boards often damaged the integrity of key morphological features, including wing venation, microtrichia, and antennal segmentation, which are useful for accurately identifying *D. oxycoccana* adults. Identification was marginally enhanced on the white boards, largely because of the color contrast with the insect abdomen, which is often bright orange in *D. oxycoccana* females.

Table 5. Infestation of rabbiteye and southern highbush blueberry buds by *D. oxycoccana*, Windsor, FL (2002)

Bud type	Mean ± SEM of *D. oxycoccana* per 420 buds	
	Egg	Larva
Rabbiteye floral	17.3 ± 6.3b	133.5 ± 32.4a
Rabbiteye leaf	13.3 ± 2.0b	12.0 ± 6.4b
Southern highbush floral	7.3 ± 4.6b	16.8 ± 4.7b
Southern highbush leaf	56.0 ± 11.3a	5.0 ± 2.6b

Means within columns followed by the same letter are not significantly different, $P > 0.05$, LSD test. Analyses were performed on square-root transformed data, but means shown reflect untransformed data.

In our sampling techniques study, we found that the emergence technique generally performed better than unbaited yellow sticky traps or the dissection technique for detecting *D. oxycoccana* adults. Emergence and dissection techniques performed equally well for detecting *D. oxycoccana* larvae. The presence of larvae on sticky boards was likely due to wind disturbances as the larvae were dropping from buds to pupate in the soil. In contrast, eggs were only detected by carefully dissecting infested buds. Although bud dissection is time consuming, the ability to detect *D. oxycoccana* eggs is important because this information could be used by blueberry growers to make insecticide applications either before eggs hatch or before additional females begin laying eggs. Ultimately, it may be possible to manage *D. oxycoccana* infestations effectively using a limited number of properly timed sprays.

The phenological differences between rabbiteye and southern highbush blueberry plants may account for differences in infestation by *D. oxycoccana.* In general, flower bud development of most southern highbush cultivars occurs before leaf bud development and before populations of *D. oxycoccana* peak in the field. Perhaps this phenological difference is the rea-

Table 6. Infestation of rabbiteye and southern highbush blueberry buds by *D. oxycoccana*, Windsor, FL (2003).

Bud type	Mean ± SEM of *D. oxycoccana* per 420 buds			
	Egg	First instar	Second instar	Third instar
Rabbiteye floral	27.5 ± 7.9a	61.0 ± 16.9a	108.0 ± 6.3a	12.3 ± 4.7a
Rabbiteye leaf	31.3 ± 8.2a	3.8 ± 1.9bc	0.3 ± 0.3b	0.0 ± 0.0b
Southern highbush floral	0.0 ± 0.0b	13.5 ± 4.3b	0.3 ± 0.3b	0.0 ± 0.0b
Southern highbush leaf	52.5 ± 15.5a	1.0 ± 0.4c	0.0 ± 0.0b	0.0 ± 0.0b

Means within columns followed by the same letter are not significantly different, $P > 0.05$, LSD test. Analyses were performed on square-root transformed data, but means shown reflect untransformed data.

son why southern highbush floral buds had the fewest number of *D. oxycoccana* eggs in both years that we sampled. Climatic conditions vary greatly from year to year during the spring growing season in Florida, which may influence *D. oxycoccana* densities. It is possible that susceptible stages of floral bud development may coincide with *D. oxycoccana* pressure. For instance, a mild winter may allow *D. oxycoccana* populations to build up early in the blueberry production season, whereas a hard freeze in February or March may kill any *D. oxycoccana* that are already developing inside infested buds.

Overall, we recorded the highest incidence of *D. oxycoccana* eggs in southern highbush leaf buds, both in 2002 and 2003. However, larval infestation of southern highbush leaf buds never exceeded that of the other bud types we evaluated. This phenomenon may indicate that survivorship of *D. oxycoccana* infesting southern highbush cultivars may be reduced compared with rabbiteye cultivars. The reason why southern highbush flower buds contained more eggs yet fewer larvae is unknown, but it is possible that the structure or the nutritional value of rabbiteye buds is more conducive to the development of *D. oxycoccana* than southern highbush buds. The significantly higher number of *D. oxycoccana* larvae in rabbiteye floral buds compared with other bud types further supports this idea. However, laboratory studies must be conducted to prove or disprove these hypotheses.

The observation of platygastrid wasps in buds collected for our emergence and dissection treatments was notable. Although we never witnessed the emergence of these wasps from *D. oxycoccana* larvae, their role as a potential parasitoid was recognized.

The number of eggs in the various types of buds we compared may lend insight regarding the oviposition preference by *D. oxycoccana* females. One factor that may vary from one bud type to another is surface lipid composition, which may influence plant examination and egg-laying behavior. Eigenbrode and Espelie (1995) discuss the variation in epicuticular waxes of plants within and among species, indicating that their presence may not only prevent plant dehydration but also mediate interactions between plants and insects. In another cecidomyiid, the Hessian fly, *Mayetiola destructor* (Say), laboratory studies showed that the extractable surface lipids of wheat increased the number of eggs laid by females compared with chloroform controls (Harris and Rose 1990). Comparisons between rabbiteye and southern highbush surface lipid composition, as well as various cultivars within these species, may complement future laboratory studies to determine oviposition preference by *D. oxycoccana* females.

Overall, our studies demonstrate that *D. oxycoccana* adults show little preference to various colors of sticky boards in the field. The emergence technique was the most effective tool we evaluated for detecting *D. oxycoccana* adults, whereas emergence and dissection techniques were equally effective for detecting *D. oxycoccana* larvae. *Dasineura oxycoccana* eggs are easily detected in infested buds by using a dissection technique, which may be valuable to growers if they are able to make insecticide applications before larvae hatch or before females begin laying additional eggs.

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