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SEASONAL DISTRIBUTION AND EVALUATION OF TWO TRAP TYPES FOR MONITORING GRAPE ROOT BORER *VITACEA POLISTIFORMIS* (LEPIDOPTERA: SESIIDAE) IN FLORIDA VINEYARDS

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ABSTRACT

Sixteen vineyards from 4 grape-growing regions across Florida were evaluated for seasonal distribution and presence of grape root borer (GRB), *Vitacea polistiformis* Harris (Lepidoptera: Sesiidae), during 2003 and 2004. Vineyards consisted of both muscadine (*Vitis rotundifolia* Michx.) and bunch grapes (*Euvitis* spp.). Grape root borer males were caught in all vineyards with Universal Moth Traps baited with female GRB pheromones, with higher captures in the northern and southern counties. Grape root borers began emerging in late Jun and early Jul in the Panhandle and southern regions. Emergence occurred in late Jul in the north-central region and in mid-Aug in the central region. Weekly trap catches indicated that peak GRB flights occurred during mid-to late Aug for the Panhandle region. In the north-central, central, and southern regions, peak flights occurred in the second and third week of Sep, coinciding with the period of grape harvest for muscadine grapes. The emergence period ceased with the onset of colder temperatures as the grapevines approached dormancy. Wing-style sticky traps were compared with Universal Moth Traps (bucket traps) in 2003 and 2004. Bucket traps were more effective and caught significantly more GRB than wing traps during both years of the study.

Key Words: grape root borer, *Vitacea polistiformis*, seasonal distribution, monitoring, pheromones, trapping

RESUMEN

Se evaluaron dieciséis viñas en cuatro regiones productoras de uva en Florida para determinar la presencia del perforador de la raíz de la uva, *Vitacea polistiformis* Harris (Lepidoptera: Sesiidae), en el 2003 y 2004, en viñas con uvas de vino (*Vitis rotundifolia* Michx.) y en uvas de mesa (*Euvitis* spp.). Los machos del perforador de la raíz de la uva fueron capturados en trampas universales para lepidopteras (Universal Moth Trap) usando la feromona producida por la hembra. El mayor número de polillas fue capturado en los condados localizados en el norte. El perforador de la raíz de la uva comenzó a emerger a finales de Junio y principios de Julio en el Panhandle y en las regiones del sur. La emergencia de los adultos ocurrió a finales de Julio en la región norte-central y a mediados o finales de Agosto en la región central. Capturas semanales indican que entre mediados y finales agosto se alcanzó el pico de la población en la región del Panhandle. En la región norte-central, central, y sur, la máxima población fue capturada durante la segunda semana o tercera semana de septiembre, coincidiendo con los periodos de cosecha de las uvas muscadine. El final del periodo de emergencia coincidió con las temperaturas frías, y el comienzo de la dormancia de las viñas. Trampas adhesivas fueron comparadas con las trampas universales en el 2003 y 2004. Las Trampas universales capturaron un número de polillas significantemente alto comparado con las trampas adhesivas en ambos años del estudio.

Translation provided by the authors.

Grape acreage has increased significantly over the past several years in Florida. The 2 most widely planted species are muscadine grapes, *Vitis rotundifolia* Michx. and hybrid bunch grapes, *Euvitis* spp. (Vitaceae). Despite an increase in the production of grapes, the grape root borer (GRB), *Vitacea polistiformis* (Harris) (Lepidoptera: Sesiidae) is the greatest insect deterrent to grape growing in the southeastern United States. It is the key pest of grapes in several states, including Georgia (All et al. 1989), North Carolina (McGiffen & Neunzig 1985) and Florida (Liburd et al. 2004).

Large infestations of GRB result in the death of vines, and smaller infestations weaken plants and reduce yields. Currently, chlorpyrifos (Lorsban 4E), applied as a soil drench, is one of the few chemical control tactics available to growers (Weihman & Liburd 2006). In order for chlorpyrifos to be effective, it must be applied during the period in which it can kill the most GRB. Understanding the seasonal distribution of the GRB, its

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peak emergence periods, data on trap effectiveness, and information on monitoring, are essential for coordinating efforts and development of control tactics for GRB.

Snow et al. (1991) and Webb et al. (1992) investigated the seasonal distribution of GRB and found that, in Florida, GRB generally begin to emerge in Jun and continue until the onset of colder temperatures. They found that peak emergence was generally bimodal. Since the findings were published, new muscadine and bunch grape hybrids have been planted (Gray 2003). In order to detect any changes that may have occurred in GRB flight patterns over a 10-year period (1993-2003), populations of GRB were monitored in the major grape-growing regions of Florida during 2003 and 2004. The overall goals of this study were twofold. Our first objective was to monitor vineyards across Florida to determine seasonal trends of GRB, specifically the initiation of emergence, peak flight periods, and the cessation of GRB activity. We increased the scope of the studies previously conducted by Snow et al. (1991) and Webb et al. (1992) by using 16 vineyards in key production areas as opposed to 4 and 9, respectively.

Our second goal was to compare the overall effectiveness of traditional wing-style sticky traps with Universal Moth Traps (bucket traps) for use in monitoring GRB. The wing-style sticky trap has been used for monitoring in all the previous GRB pheromone and mating disruption studies (Johnson et al. 1986; Johnson et al. 1991; Snow et al. 1987; Snow et al. 1991; Webb 1991; Webb et al. 1992). The problem with wing traps is that they become inundated with insects and debris and need to be replaced on a regular basis to be effective. These 2 trap styles have been compared in previous studies with other lepidopteran pests, and in each study, the bucket traps caught significantly more moths than the wing traps (Shaver et al. 1991; Schmidt & Roland 2003). A better trapping device would alleviate some of the problems discussed previously.

Materials and Methods

Monitoring

Pheromone monitoring of GRB was carried out in 16 vineyards in 2003 and 2004, representing 4 distinct grape-growing regions of Florida (Fig. 1). Sixteen privately owned vineyards were chosen in 4 areas: the Panhandle [including one vineyard each in Washington (1), Calhoun (2), Leon (3), and Jefferson (4) Counties], north-central Florida [1 vineyard in Alachua County (5) and 3 vineyards in Putnam County (6-8)], mid-Florida [four vineyards in Lake County (9-12)], and south-central Florida [including 1 vineyard in Hillsborough County (13), 2 in Manatee County (14,15), and 1 in Highlands County (16)]. Vineyards were chosen with similar cultural practices and grape types (muscadine and bunch grapes).

Four green Universal Moth Traps (bucket traps) (Great Lakes IPM, Vestaburg, MI) baited with female GRB pheromone (99% (*E,Z*)-2,13-octadecadienyl acetate, 1% (*Z,Z*)-3,13-octadecadienyl acetate) (1 mg of pheromone per septum) (Great Lakes IPM, Vestaburg, MI) were placed in each vineyard. Traps were distributed evenly throughout each vineyard, at least 30 m apart. The baits in the bucket traps were changed once per season, at the midpoint of the GRB emergence period for the specific region (approximately 2 months). A Vaportape (Hercon Environmental, Emigsville, PA) treated with 2,2-dichlorovinyl dimethyl phosphate was affixed to the bottom of each trap within the bucket to kill the GRB as they became entrapped. Traps were hung from the trellis wire approximately 1 to 1.5 m above the ground near the vine trunk.

Monitoring began in Jun each year, according to Webb et al. (1992), who demonstrated that the first emergence of GRB in our regions began in Jun or later. Trap contents were collected weekly into labeled plastic resealable bags and taken to the Small Fruit and Vegetable IPM Lab at the University of Florida in Gainesville for analysis. The number of GRB, along with other insects collected in each trap, was recorded each week. Traps were continuously monitored until no more borers were caught.

Evaluation of Traps

This study was carried out at 3 sites in 2003 and expanded to 5 sites in 2004. In 2003, traps were placed in 3 vineyards representing different areas of Florida: the Panhandle (vineyard #2) (Calhoun County), mid-Florida (vineyard #10) (Lake County), and the south-central grape-growing region of Florida (vineyard #13) (Hillsborough County) (Fig. 1). For 2004, 2 vineyards in the north-central region in Alachua County (vineyard #17) and Putnam County (vineyard #18) were added to the original 3 locations (Fig. 1).

The 2 traps compared for this experiment were Universal Moth Traps dimensions ~13.2 × 20.4 cm, and wing-style sticky traps ~20.4 × 16.8 cm (dimensions of sticky surface). Both traps were baited with GRB pheromone, 99% (E, Z)-2,13 octadecadienyl acetate and 1% (Z, Z)-3,13 octadecadienyl acetate (Great Lakes IPM, Vestaburg, MI). Pheromone lures were changed once per season, after 8 weeks.

Traps were hung from the trellis wires at approximately 1.5 m above the ground, and spaced at least 30 m apart. The experimental design was a Completely Randomized Block with 6 and 10 replicates during 2003 and 2004, respectively. Traps were set out at the beginning of the GRB emergence period for each region, late Jun for the

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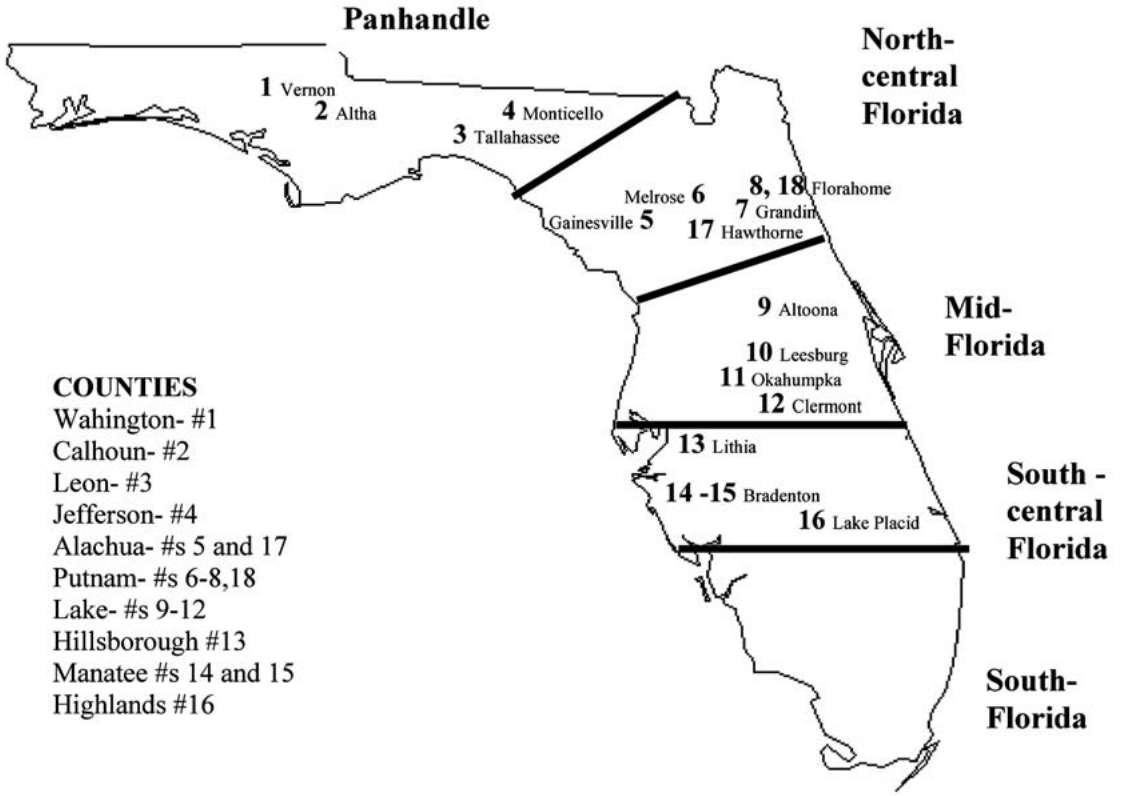


Fig. 1. Map of Florida showing the locations of the 16 vineyards involved in the grape root borer survey (vineyards 1-16). Vineyards 2, 10, 13, 17, and 18 were used in the trapping study.

Panhandle and south, and early Jul for the central regions. Traps were serviced weekly.

Statistical Analysis

Monitoring Studies. Trap catches were counted and recorded weekly for the entire emergence period (16 weeks) during 2003 and 2004 and the mean number of GRB per vineyard per week was reported.

Evaluation of Traps. Trap catches were counted and recorded weekly for the entire emergence period. In 2003 there were 18 weekly samples and in 2004 there were 16. Total number of GRB weekly captures was analyzed by Repeated Measures Analysis of Variance (ANOVA) and differences were evaluated by using a paired *t*-test ($\alpha = 0.05$) (SAS Institute 2004).

RESULTS

Monitoring

Table 1 shows the first emergence, peak emergence, and last captures of GRB in all vineyards for the entire season in 2003 and 2004. Overall, the timing of the peaks of emergence generally coincided for vineyards within the same region.

In the Florida Panhandle, activity began in late Jun-early Jul (Table 1). Male GRB moth peak flight occurred in mid- to late Aug in both 2003 and 2004, except for 2 vineyards, whose peaks occurred in early Sep in 2004. Grape root borer ceased activity during the first week of Oct for most Panhandle vineyards.

In the north-central region, GRB emerged in mid- to late Jul for most vineyards, with a few exceptions: Jul 2 (vineyard 6, 2004) and Aug 13 (vineyard 7, 2003) (Table 1). Peak flights occurred mostly during the second week of Sep in 2003. In 2004, the peak flights occurred at the beginning of Oct, later than the previous year. Grape root borer adults stopped emerging the third and fourth weeks of Oct.

In the mid-Florida region (Lake County), GRB mostly emerged in mid- to late Aug (Table 1). This was later than all other areas monitored. Peak flight occurred mostly in the second and third weeks of Sep. Generally, GRB activity ceased in Oct.

In the south-central grape-growing region of Florida, GRB began emerging at the end of Jun and early Jul (Table 1). Emergence peaked in the

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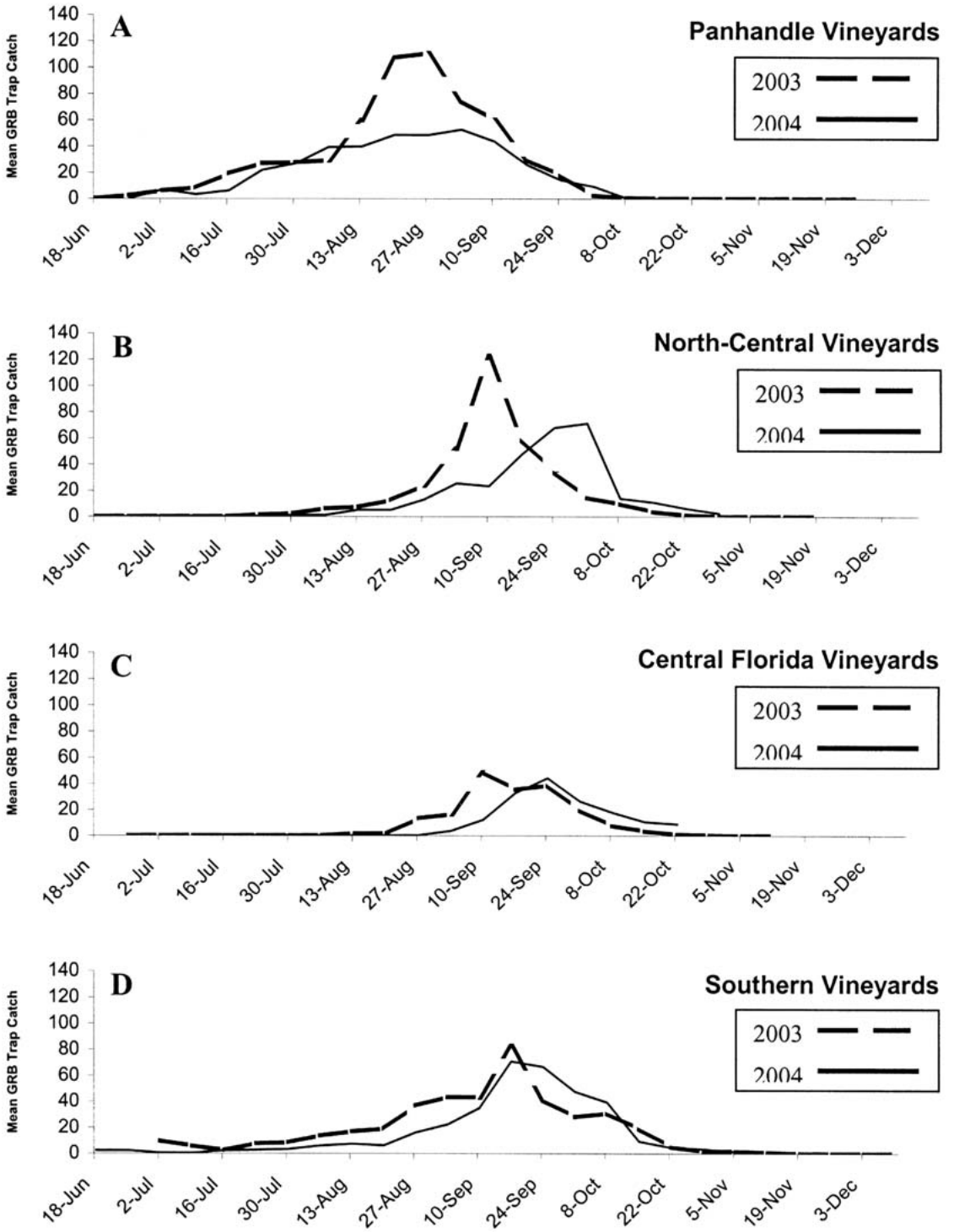


Fig. 2. Seasonal distribution of GRB in 4 regions of Florida: (A) Panhandle, (B) North-Central, (C) Central, and (D) Southern. The data from 4 vineyards within each region were pooled for 2003 and 2004.

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TABLE 1. FIRST AND PEAK GRAPE ROOT BORER EMERGENCE IN 16 FLORIDA VINEYARDS BY REGION, 2003-2004.

Region	Vineyard	First emergence 2003	Peak emergence 2003	Last capture 2003	First emergence 2004	Peak emergence 2004	Last capture 2004
Panhandle	1	Jun 25	Aug 20	Oct 1	Jul 2	Aug 20	Oct 1
	2	Jun 25	Aug 13	Oct 22	Jul 2	Aug 27	Oct 1
	3	Jul 2	Aug 27	Oct 8	Jul 2	Sep 3	Oct 8
	4	Jun 18	Aug 27	Oct 1	Jul 2	Sep 3	Oct 1
North-central	5	Jul 23	Sep10	Oct 22	Jul 23	Oct 1	Oct 28[b]>
	6	Jul 16	Sep 10	Oct 22	Jul 2	Oct 1	Oct 21
	7	Aug 13	Sep 10	Oct 15	Jul 30	Oct 1	Oct 28[b]>
	8	Jul 30	Aug 27	Oct 15	Jul 30	Sep 10	Oct 28[b]>
Central	9	Aug 13	Sep 10	Oct 22	Aug 27	Oct 1	Oct 26[b]>
	10	Aug 27	Sep 10	Oct 1	Jul 9	Sep 24	Oct 26[b]>
	11	Aug 6	Sep 24	Oct 8	Sep 4	Sep 24	Oct 26[b]>
	12	Aug 13	Sep 24	Oct 29	Jul 1	Sep 24	Oct 26[b]>
South-central	13	<Jul 2[a]	Sep 17	Nov 5	<Jun 18[a]	Sep 17	Nov 5[b]>
	14	Jul 2	Sep 10	Nov 5	Jun 25	Sep 14	Nov 5[b]>
	15	Jul 2	Sep 10	Dec 10	Jun 25	Aug 27	Nov 5[b]>
	16	Jul 2	Oct 8	Nov 12	Aug 6	Sep 24	Nov 5[b]>

[a]<, GRB were caught the first week of monitoring and may have emerged sooner than data indicates.
[b]>, GRB were caught on the last day of monitoring and additional GRB may have emerged after specified date.

second and third weeks of Sep at the vineyards nearer to the coast and in the first week of Oct at the inland vineyard (vineyard 16). In 2004, the peaks occurred from late Aug to mid-Sep, with the inland peak (vineyard 16) slightly later than the coastal peaks (vineyards 13, 14, 15) in the third week of Sep. The GRB flight period ended for the south-central region in the first few weeks of Nov for most vineyards.

Overall, adult GRB activity lasted for approximately 3.5 months [late Jun to early Oct (Fig. 2A)] in the Panhandle region, 4 months in North-central Florida [Jul through Oct (Fig. 2B)], 3-3.5 months in mid-Florida [Aug through Oct (Fig. 2C)], and 5-5.5 months in the south-central region [Jun-Nov (Fig. 2D)]. Peaks were higher in the 2 northern areas (Fig. 2A, B) than in the central and southern regions. Overall, the central region had the shortest GRB flight period (Fig. 2C) and the southern region had the longest (Fig. 2D). The GRB flight season ended earliest in the Panhandle (Fig. 2A).

The mean (+ S.E.M) trap captures of GRB for each vineyard for 2003 and 2004 are reported in Fig. 3. In 2003, the mean (± SEM) weekly GRB trap catch for all vineyards was 20.3 ± 6.5, and in 2004, it was 16.1 ± 4.9. Overall trap catches varied among vineyards, with the central region (vineyards 9-12) having the lowest populations. Fewer GRB were caught in 2004 compared with 2003, but this reduction was not significantly different.

Evaluation of Traps

For the 2003 GRB emergence period, the mean (± SEM) GRB trap catch per week was 10.2 ± 2.6 (84%) for the bucket trap and 1.9 ± 0.6 GRB (16%) for wing traps, more than 5-fold difference (Table 2). Bucket traps caught significantly more GRB than the wing traps on a weekly basis (t = 2.00; df = 1, 106; P = 0.0020) (Table 2). In 2004, bucket traps caught 11.1 ± 2.3 GRB (66%) and wing traps caught 5.7 ± 1.1 (34%) (Table 2). Overall, bucket traps captured significantly more GRB per week than wing traps (t = 1.98; df = 1,158; P = 0.0392) (Table 2). Additionally, the percentage of zero trap captures was lower in bucket traps than in wing traps (Table 2).

DISCUSSION

Monitoring

The results of the monitoring experiments indicate that GRB were present in all of the vineyards studied. Our study corroborates the earlier work of Snow et al. (1991) and Webb et al. (1992). However, significantly more vineyards were evaluated in the current work, indicating that the problem of GRB infestation in Florida vineyards is more severe than previously thought. In addition, newer vineyards (1993-2003) with grape hybrids did not show a significant change in the potential to be infested with GRB. The results were useful in showing the general emergence patterns and peak flight activities for GRB in these 4 regions of Florida. Overall, the results show that GRB begin emerging in late Jun or early Jul in the Panhandle and south-central region of the state, but later for the north-central and central regions. The peak flights occur in late Aug in the

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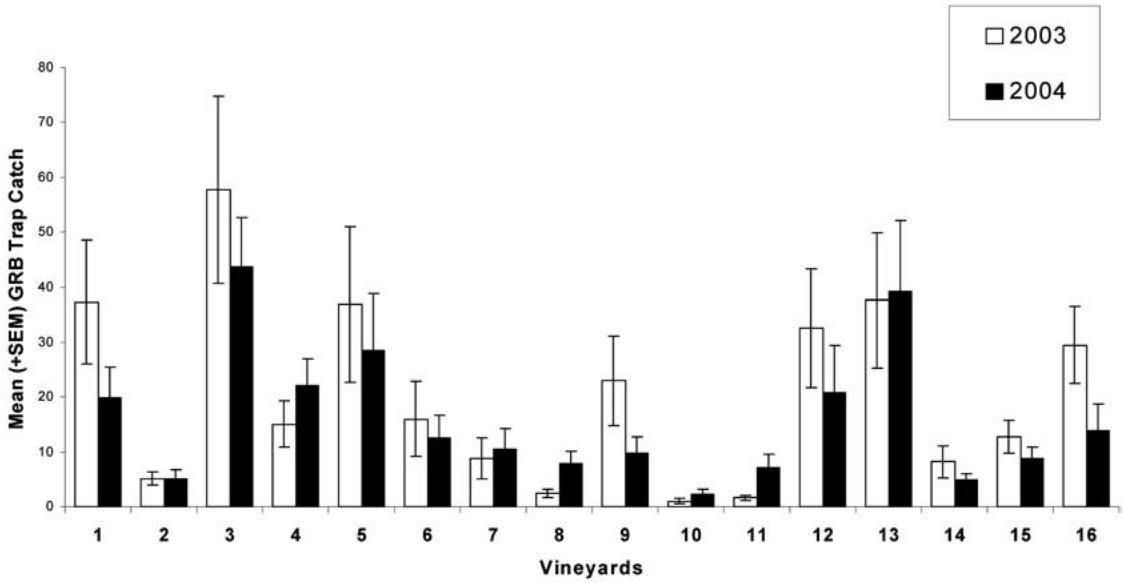


Fig. 3. Mean (± SEM) grape root borer trap catch in 16 Florida vineyards, 2003-2004.

Panhandle and generally occur around mid- to late Sep for the rest of the state. In contrast to previous research, which suggested a bimodal GRB peak emergence in the southern end of the GRB range, most of the peaks observed in the current study were single, although a few bimodal peaks did occur. Differences in seasonal distribution between our work and earlier findings may be attributed to changes in weather conditions, as opposed to the occurrence of a true 'two-phase' emergence. During weeks of unseasonably cold temperatures, fewer GRB were usually caught. Another factor may be the use of bucket traps in this study versus wing traps used in the previous work. Wing traps are incapable of capturing the volume of moths we caught in bucket traps on a weekly basis during peak emergence.

The Panhandle had the highest GRB trap catch during the 2 years of this study, which may be due to its having a richer, more moisture-retentive soil than that found lower in the peninsula of Florida. There was a slight reduction in regional total trap catches from 2003 to 2004 as well as mean (± SEM) GRB trap catch from 2003 to 2004. The number of GRB decreased in 10 of the 16 vineyards monitored. In 2004, a dry spring resulted in slower growth of the vines and set harvest back several weeks for most areas. It is interesting to note that grape harvest occurred 2 weeks later in 2004, and the GRB peak emergence occurred 2 weeks later than the previous year as well. This suggests that the GRB life cycle may be highly synchronized with grape plant phenology, as proposed by Dutcher & All (1978).

The results of our monitoring study have direct applications. The GRB emergence information can help growers to optimize the timing of their chlorpyrifos application or other tactics for the control of GRB in grapes. For example, in the Panhandle, the GRB peak coincides with the muscadine grape harvest, around the third and fourth weeks of Aug. Our results show that if

TABLE 2. TOTAL GRAPE ROOT BORER CATCHES, MEAN (+ SEM) WEEKLY CAPTURES, AND FREQUENCY OF WEEKS WITH ZERO CAPTURES FOR TWO TRAP TYPES, 2003-2004.

	Trap catch		Weekly mean		Zero frequency (%)	
Trap type	2003	2004	2003	2004	2003	2004
Bucket	553	884	10.24 ± 2.55 A	11.05 ± 2.33 a	33.7%	41.6%
Wing	104	455	01.93 ± 0.63 B	05.69 ± 1.11 b	62.2%	53.2%

Weekly mean trap catch for 2003 (t = 1.99; df = 1, 106; P = 0.002) and 2004 (t = 0.98; df = 1,158; P = 0.0392) with t-pairwise comparison (α = 0.05). Means followed by upper-case letters represent differences for 2003 and lower-case letters represent differences for 2004.

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farmers were to apply chlorpyrifos 35 days preharvest (as suggested by the post harvest interval [PHI] label), they would only be able to affect a small percentage of the GRB population. According to our study, it would be best to apply it directly after harvest to maximize the potential number of GRB killed, which could affect subsequent generations. Similarly, in the 3 more south-central regions, GRB peaks occur mostly 1 to 2 weeks after muscadine grape harvest begins, during the third and fourth weeks of Aug, so chlorpyrifos applications would be optimized if applied after harvest.

Bunch grapes, however, are ready for harvest at the end of Jun and throughout Jul in Florida, depending on the region. As with muscadine grapes, our study suggests that the application of chlorpyrifos would be best timed after harvest and slightly after the peak GRB emergence for that area.

Evaluation of Traps

Bucket traps caught significantly more GRB than did wing traps during both seasons. Also, the wing trap treatments had higher percentages of zero weekly counts (62.2 and 53.2%) than did the bucket traps (33.7 and 41.6%). The poorer performance of the wing traps may be due to the fact that they become saturated with GRB moths, other insects, and plant debris over the period of their use. This reduces the sticky surface and diminishes the effectiveness of the trap over time.

Some studies suggest that the wing trap may be more effective at low population densities, but Schmidt & Roland (2003) showed the opposite to be true for forest tent caterpillar, *Malacosoma disstria* Hubner (Lepidoptera: Lasiocampidae). Most importantly, in our monitoring experiment, we often had weekly trap catch numbers of 40 to 70 in the bucket traps with highs in the 150-170 range during peak emergence. Wing traps are incapable of capturing this volume of moths. The wing trap can be an effective monitoring device, but would need to be changed daily during periods of such high activity. Clearly, the bucket trap is the superior GRB trap for use by growers.

Several factors may contribute to the greater effectiveness of bucket traps. The bucket trap has a more open design than the wing trap. The pheromone cage at the top allows the plume to be dispensed relatively uninterrupted whereas the wing trap is closed on 2 sides, and this may distort the plume structure. The bucket trap's success may also be attributable to its trapping method. The moths are trapped within a lower enclosure and killed quickly by the Vaportape inside the traps. Moths trapped on sticky boards have greater opportunity to escape via other debris, autotomy, or perhaps being near the edge of the sticky surface.

In addition to its greater efficiency, the bucket trap may be more cost-effective in the long run. The bucket trap is more expensive initially, at $8.95 per trap (Great Lakes IPM, Vestaburg, MI), whereas the wing trap is only $2.32 per trap (IPM Tech, Portland, OR). However, bucket traps are more durable and can be used year after year. They are easy to assemble and are placed in the field once per season. Due to the frequency with which wing traps need to be changed, they would be more costly per season than bucket traps, in addition to their higher labor demands.

For monitoring purposes, the bucket trap is easier to use and gives a more accurate insect count, as shown by the current data. A saturated sticky board is often difficult to count; exposure to the elements leads to rapid deterioration. Predators, such as lizards and frogs, are often observed on the sticky boards, along with partially eaten GRB moths.

The bucket traps used in this study were green in color. There are no previous studies indicating a trap color preference for GRB, or other sesiid moths. Shaver et al. (1991) caught significantly more Mexican rice borers *Eoreuma loftini* (Dyar) with green-yellow-white traps than with all green. One possibility for the higher number of zero counts for the wing traps may be a different behavioral response due to the trap design or color. Future studies should focus on trap colors as well as optimal trap density.

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