Trap Capture of Brown and Dusky Stink Bugs (Hemiptera: Pentatomidae) as Affected by Pheromone Dosage in Dispensers and Dispenser Source[1]

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Abstract Brown, *Euschistus servus* (Say), and dusky, *E. tristigmus* (Say), stink bugs (Heteroptera: Pentatomidae) readily respond to traps baited with the *Euschistus* spp. aggregation pheromone methyl (E, Z) -2,4-decadienoate. Previous studies examining trap capture of these stink bugs have used either laboratory-prepared dispensers or commercial dispensers with various known and unknown pheromone doses. We compared trap captures of *E. servus* and *E. tristigmus* using yellow pyramid traps baited with a range of pheromone doses (20 - 120 μL) loaded onto rubber septa and when baited with 2 commercially available pheromone dispensers. These baited traps were located primarily in or alongside pecan orchards with one exception being alongside a peach/plum orchard. Traps were monitored weekly for 4 wk during 2008 and 2009. Dispensers were either replaced weekly or the same dispenser remained in use for the entire study. All pheromone doses tested resulted in a numerical increase of both *E. servus* and *E. tristigmus* captured in traps compared with traps using no pheromone. In each experiment for each species, at least one pheromone dose significantly increased trap capture compared with traps using a septa containing no pheromone. In direct comparisons, neither commercial dispenser ever captured significantly more *E. servus* or *E. tristigmus* than traps without pheromone. Numerically higher trap captures were observed with a higher pheromone dose in each of 5 month-long studies. However, captures were not always significantly higher for either species suggesting that other factors affected stink bug capture in pheromone-baited traps. Results from this study could facilitate the use of this stink bug trap as a barrier to impede movement of pest *Euschistus* spp. into orchards or other crop habitats.

Key Words *Euschistus servus*, *Euschistus tristigmus*, stink bug, pheromone, methyl (2E, 4Z)-decadienoate

Brown stink bug, *Euschistus servus* (Hemiptera: Pentatomidae), is a highly problematic, polyphagous pest of numerous row and orchard crops (Woodside 1946, Rolston and Kendrick 1961, Jones and Sullivan 1982, Tedders et al. 1990). In southeastern U.S. peach and pecan orchards, currently available control options are at best marginal. Recommendations for stink bug control rely heavily on pyrethroid insecticides in peach (Horton et al. 2010) and pecan (Hudson et al. 2010). However, *E. servus* is still very difficult to control due to its inherently low susceptibility to many of these insecticides and/or the short residual activity of these materials (Tillman and

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Mullinix 2004). Control difficulties are often compounded by large numbers of highly mobile *E. servus* adults continuing to move into orchards for multiweek periods of time.

Stink bug populations are assessed using a variety of sampling methods including sweep net, beat sheet, visual observation, black light traps, D-vac, Malaise traps and insecticide knockdown sprays (Dutcher and Todd 1983, Rashid et al. 2006, Nielsen and Hamilton 2009, Reay-Jones et al. 2009, Kamminga et al. 2009). Stink bugs of several species also can be trapped using a yellow pyramid trap (Mizell and Tedders 1995, Rashid et al. 2006). *Euschistus* spp. aggregation pheromone, i.e., methyl (E, Z) -2,4-decadienoate (Aldrich et al. 1991), is attractive to males and females of at least 5 *Euschistus* spp. When the yellow pyramid trap is baited with methyl (E, Z) -2,4-decadienoate, capture of *Euschistus* spp. stink bugs is dramatically increased. Use of enhanced pheromone trapping may become a useful tool as badly needed management options are developed for *Euschistus* spp., especially *E. servus*.

The capture efficiency of yellow pyramid traps baited with a *Euschistus* spp. aggregation pheromone may be such that border trapping could be useful to limit movement of *Euschistus* spp. into orchards. Studies using the combination of the aggregation pheromone and the yellow pyramid trap have shown that both *E. servus* and the dusky stink bug, *E. tristigmus*, are commonly captured (Cottrell et al. 2000, Leskey and Hogmire 2005, Hogmire and Leskey 2006, Leskey and Hogmire 2007). Yonce and Mizell (1997) found that 93% of stink bugs captured in pheromone-baited traps in a Georgia pecan orchard were *E. servus* and *E. tristigmus*. In previous studies (Cottrell et al. 2000, Leskey and Hogmire 2005, Hogmire and Leskey 2006, Leskey and Hogmire 2007), the same pyramid base design (Tedders and Wood 1994) painted yellow (Mizell et al. 1997) was used, but these studies used different stink bug collection devices, with or without an insecticide ear tag, attached to the top of pyramid traps. It was determined that retention of captured stink bugs can be affected by the size of the opening in the collecting device and/or the presence of the insecticide ear tag to kill captured stink bugs (Cottrell 2001, Leskey and Hogmire 2005, Hogmire and Leskey 2006). Additionally, attraction to and capture in traps is affected by the type of pheromone dispenser used (Leskey and Hogmire 2005). Dispensers used in previous studies have been either commercial baits or baits prepared in the laboratory (Cottrell et al. 2000, Leskey and Hogmire 2005, Tillman et al. 2010).

The research reported in this study is a component of a larger body of research examining new approaches for *E. servus* management. Our study compared *E. servus* and *E. tristigmus* captures with varying doses (0 - 120 μL) of the *Euschsitus* spp. aggregation pheromone loaded onto rubber septa versus traps baited with the 2 commercial dispensers. Additionally, dispenser efficacy (using 0 - 120 ul doses and dispensers from 2 different commercial sources) was compared at weekly and 4-wk intervals.

Materials and Methods

Traps and pheromone dispensers. Stink bug traps were made by painting pyramid traps (Tedders and Wood 1994) yellow and enlarging the insect-collecting device (Mizell and Tedders 1995). The insect-collecting device was modified from that used by Mizell and Tedders (1995) in that it was made from a 2.8-l clear plastic PET® jar (United States Plastic Corp., Lima, OH), as described previously by Cottrell et al. (2000), and seated atop the 1.22-m-tall yellow pyramid base. An insecticidal ear tag

(10% λ-cyhalothrin and 13% piperonyl butoxide) (Saber Extra insecticide ear tags, Schering-Plough Animal Health Corp., Union, NJ, USA) was placed in the collecting device to decrease stink bug escape (Cottrell 2001, Hogmire and Leskey 2006).

The *Euschistus* spp. aggregation pheromone (methyl [E, Z] -2,4-decadienoate, CAS registry no. 4,493 - 42 - 9), was purchased from Degussa AG Fine Chemicals (Marl, Germany) and stored at −20°C until used. Dispensers were produced by pipetting desired pheromone doses (0 - 120 μL; see Table 1) into the opening of rubber septa (11 mm natural, red rubber sleeve stoppers, Wheaton, Millville, NJ, USA), holding septa upright in a laboratory rack, and allowing septa to absorb the pheromone at room temperature. These newly-prepared pheromone dispensers were stored in glass jars with a metal lid at −20°C until used in experiments. Commercially-prepared dispensers included the Scenturion® wax type *Euschistus* spp. dispenser (Stink Bug 12966, Suterra®, Bend, OR, USA) and a septa dispenser for *Nezara, Euschistus, Chlorochroa* (CSB 3237-25 Pherocon Cap, Trécé, Inc., Adair, OK, USA).

Experiments 1 - 5. Five experiments were conducted during 2008 and repeated during 2009 at the 460 ha USDA, ARS, Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA, USA (Table 1). All experiments were conducted in pecan orchards using 5 or 10 replicates (Table 1) with the exception of experiments 1 (2009 only) and 5 (2008 and 2009) that had 2 of the 5 replicates placed in pecan orchards and the 3 remaining replicates alongside the edge of peach/plum orchards. For experiments 1 - 4, a replicate consisted of a line of traps, spaced 50 m apart, with the number of traps equal to the number of treatments used for each experiment (Table 1). Experiment 5 was conducted the same except that traps were spaced 122 m apart. Traps in pecan orchards were positioned between pecan trees within the herbicide strip and at least 3 m from a pecan tree. For any trap not within a herbicide strip, nearby vegetation was regularly mowed within 5 m of the trap. All treatments were randomly assigned to traps within each replicate at the beginning of each experiment. Treatment dispensers were either replaced weekly throughout the experiment or a treatment dispenser remained in the trap for the duration of the experiment (Table 1). Traps were monitored weekly and all stink bugs were collected and taken to the laboratory for identification. Numbers of *E. servus* and *E. tristigmus* were recorded.

Dispenser weights. All dispensers used during 2009 were weighed (Mettler AE260 Delta Range, Mettler-Toledo, Inc., Columbus, OH) just before being placed in traps in the field. Dispensers that were replaced weekly were weighed after being collected from a trap and those dispensers that remained in traps for the duration of an experiment were weighed at the conclusion of that experiment.

Statistical analyses. At the end of each experiment cumulative stink bug capture, by species, was subjected to analysis of variance (ANOVA) (JMP 2007); low numbers of captured *E. tristigmus* required those data to be square root transformed (Zar 1999) and then subjected to ANOVA. All *E. tristigmus* data are presented as nontransformed means. Treatment means were separated using Tukey's Honestly Significant Difference test when a treatment difference ($P < 0.05$) was detected (JMP 2007). Beginning and ending dispenser weights for the different treatments were analyzed using a paired *t*-test (JMP 2007).

Results

Experiment 1. When traps were initially baited with dispensers containing 0, 20, 40 or 80 μL of pheromone, and all dispensers were replaced weekly during the 4-wk

Table 1. Dates, number of replicates, pheromone dose or commercial source of dispenser and dispenser replacement frequency used to study trap capture of *E. servus* in yellow pyramid traps.

Experiment	Dates	Replicates	Dispenser (dose or source)	Dispensers that were replaced weekly
1	13 May – 10 June 2008	10	0*, 20, 40 and 80 µL	0, 20, 40 and 80 µL
1	15 October – 5 November, 2009	5	0, 20, 40 and 80 µL	0, 20, 40 and 80 µL
2	Jun 30 – Jul 28, 2008	5	0, 40, 40, 80, 120 µL	40 µL
2	Oct 15 – Nov 6, 2009	5	0, 40, 40, 80, 120 µL	40 µL
3	Jun 11 – Jul 9, 2008	10	0, 40, 80, 120 µL, Sc** and Tr***	0, 40, 80, 120 µL
3	Sep 16 – Oct 14, 2009	5	0, 40, 80, 120 µL, Sc and Tr	0, 40, 80, 120 µL
4	Aug 5 – Sep 2, 2008	10	0, 40, 80, 120 µL, Sc and Tr	0, 40, 80, 120 µL, Sc and Tr
4	Sep 9 – Oct 7, 2009	5	0, 40, 80, 120 µL, Sc and Tr	0, 40, 80, 120 µL, Sc and Tr
5	Aug 5 – Sep 2, 2008	5	40 µL, Sc and Tr	40 µL, Sc and Tr
5	Aug 26 – Sep 30, 2009	5	40 µL, Sc and Tr	40 µL, Sc and Tr

*dispenser without pheromone
**Sc = Scenturion® wax type *Euschistus* spp. dispenser (Stink Bug 12966, Suterra®, Bend, OR, USA)
***Tr = *Nezara, Euschistus, Chlorochroa* dispenser (CSB 3237-25 Pherocon Cap, Trécé, Inc., Adair, OK, USA)

experiment, a significant treatment effect was detected for *E. servus* captured in traps during both 2008 and 2009 ($F = 25.93$; df = 3, 39; $P < 0.0001$ and $F = 9.32$; df = 3, 19; $P = 0.0019$, respectively) (Fig. 1A, B). Each year, traps baited with 20, 40 and 80 µL dispensers caught more *E. servus* than traps baited with septa not containing pheromone (i.e., 0 ul). More *E. servus* were captured in traps baited with 80 µL dispensers in 2008 than in traps containing 20 µL lures; capture in traps baited with 40 µL dispensers was not different from either capture with 20 or 80 µL lures. During 2009, similar numbers of *E. servus* were captured when using the 20, 40 or 80 µL lures.

For *E. tristigmus*, a significant treatment effect regarding trap capture was detected during 2008 and 2009 ($F = 13.79$; df = 3, 39; $P < 0.0001$ and $F = 4.50$; df = 3, 19, $P = 0.0245$, respectively) (Fig. 1 C, D). Traps baited with 80 µL dispensers captured more *E. tristigmus* than control traps each year, and more than the traps with 20 or 40 µL dispensers during 2008, but not during 2009 (Fig. 1 C, D).

After 1 wk in the field, dispenser ending weight was significantly less than the beginning weight for the 20 µL ($t = 7.03$; df = 19; $P < 0.0001$), 40 µL ($t = 6.77$; df = 18; $P < 0.0001$) and 80 µL ($t = 8.47$; df = 19; $P < 0.0001$) lures. Mean percentage weight loss (±SE) for these dispensers was 0.89 ± 0.12, 1.07 ± 0.16 and 2.2 ± 0.26, respectively. Although ending weight for the 0 µL dispenser was not significantly different from its beginning weight ($t = -1.66$; df = 19; $P = 0.1127$), this dispenser actually had a small, but positive, mean weight gain (0.24 ± 0.14%) in the field.

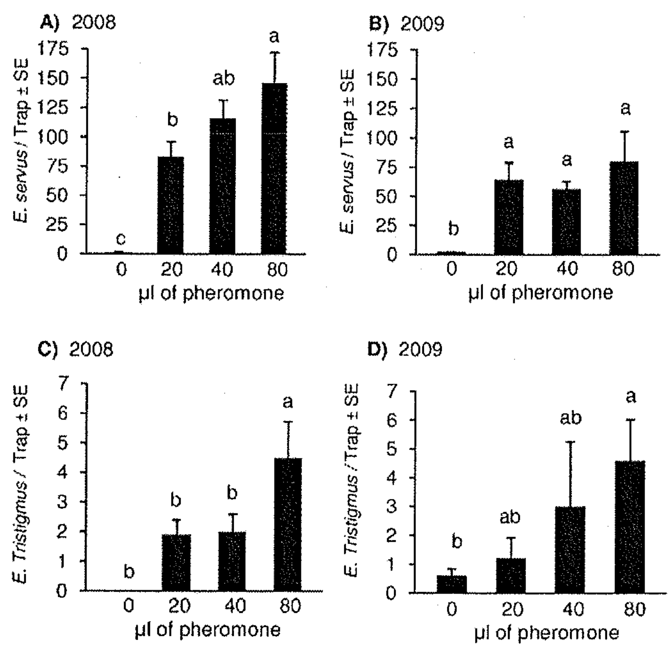

Fig. 1. Mean capture of A, B) *Euschistus servus* and C, D) *E. tristigmus* in yellow pyramid traps over a 4-wk interval from 13 May to 10 June 2008 and 8 October to 5 November 2009. Traps were baited with different doses (0, 20, 40 or 80 µL) of a *Euschistus* spp. aggregation pheromone loaded onto rubber septa. Dispensers, i.e., rubber septa, in traps were replaced each week.

Experiment 2. Traps baited with dispensers containing 0, 40, 80, and 120 µL of pheromone that were not replaced during the 4-wk experiment or baited with a dispenser containing 40 µL that was replaced weekly had a significant treatment effect on *E. servus* capture during both 2008 and 2009 ($F = 8.08$; df = 4, 24; $P = 0.0009$ and $F = 8.16$; df = 4, 24; $P = 0.0009$, respectively) (Fig. 2A, B). Whether dispensers containing pheromone were replaced weekly or not had no significant effect upon capture of *E. servus* in either year. However, during 2008, the 80 and 120 µL dispensers (not replaced during the experiment) and the 40 µL dispenser (replaced weekly), all captured significantly more *E. servus* than the blank lure. This was similarly true for the 120 µL dispenser (not replaced) and the 40 µL dispenser (replaced weekly) during 2009 (Fig. 2 A, B).

A general trend of decreasing *E. servus* capture occurred over time for traps baited with the 40, 80 and 120 µL dispensers (not replaced weekly) each year (Fig. 3A, B). Average daily temperatures during each wk of the test during July 2008 were 25.2 ± 0.5, 27.3 ± 0.2, 27.4 ± 0.5 and 27.4 ± 0.4°C, respectively. But, in October and early November 2009, average daily temperatures were variable and lower across wk 1 - 4 (20.8 ± 1.3, 13.8 ± 1.7, 17.3 ± 1.1 and 14.4 ± 0.7°C, respectively).

During 2008, numbers of *E. tristigmus* captured were low and no significant difference between treatments was detected ($F = 0.48$; df = 4, 24; $P = 0.7529$). But in 2009, traps baited with dispensers initially containing 80, 120 µL (neither replaced weekly) or 40 µL dispensers (replaced weekly) captured significantly more *E. tristigmus* than traps that used blank dispensers ($F = 7.52$; df = 4, 24; $P = 0.0013$) (Fig. 2 C). Traps using dispensers initially containing 40 µL (replaced weekly) captured significantly more *E. tristigmus* than traps using 40 µL dispensers (not replaced).

When considering only those dispensers that remained in the field for 4 wk during 2009, ending weights were significantly less than beginning weights for the 40 µL ($t = 14.72$; df = 4; $P < 0.0001$), 80 µL ($t = 17.43$; df = 4; $P < 0.0001$) and 120 µL ($t = 13.83$; df = 4; $P = 0.0002$) dispensers but not the 0-µL dispenser ($t = 1.20$; df = 4; $P = 0.2962$). Mean percentage weight loss (±SE) for the 40, 80 and 120µl dispensers was 3.74 ± 0.22, 6.35 ± 0.35 and 9.66 ± 0.56, respectively. Again, the ending weight for the 0-µL

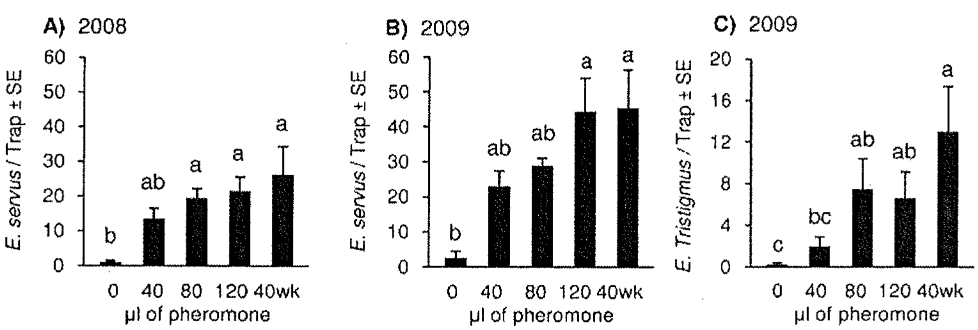

Fig. 2. Mean capture of A, B) *Euschistus servus* and C) *E. tristigmus* in yellow pyramid traps over a 4-wk interval from 30 June to 28 July 2008 and 8 October to 6 November 2009. Traps were baited with different doses (0, 40, 80 or 120 µL) of a *Euschistus* spp. aggregation pheromone loaded onto rubber septa. Dispensers, i.e., rubber septa, were not replaced each wk over the 4-wk test, except for the 40wk dispenser.

dispenser was not significantly different from its beginning weight after 4 wk in the field (t = 1.20; df = 4; P = 0.2962).

Experiment 3. When comparing *E. servus* capture in traps baited with 2 commercially available dispensers (not replaced weekly) and with dispensers initially containing 0, 40, 80 or 120 µL of pheromone (replaced weekly), a significant treatment effect was detected during 2008 and 2009 (F = 3.59; df = 5, 59; P = 0.0020 and F = 10.13; df = 5, 29; P < 0.0001, respectively) (Fig. 4A, B). During 2008, traps using the 120-µL dispenser (replaced weekly) captured more *E. servus* than traps using any other bait and also the 40, 80 and 120 µL dispensers (replaced weekly) captured more *E. servus* than either the Scenturion, Trece or blank dispensers (Fig. 4A). Again in 2009, traps baited with the 80 and 120 µL dispensers captured more *E. servus* than traps using the 2 commercially available dispensers or the blank dispenser (Fig. 4B). A significant treatment effect also was found for *E. tristigmus* during 2008 and 2009 (F = 6.41; df = 5, 59; P = 0.0001 and F = 7.84; df = 5, 29; P = 0.0003, respectively). During 2008, only traps baited with the 120 µL dispensers captured significantly more *E. tristigmus* than both the Scenturion and Trece dispensers (Fig. 4C); however, in 2009 only traps baited with the 80 µL dispensers captured more stink bugs than the Scenturion or Trece dispensers (Fig. 4D). In each year, capture of *E. tristigmus* was similar in traps baited with the Scenturion, Trece or blank lures.

After 1 wk in the field, ending weight was significantly less than beginning weight for the 40 µL (t = 9.80; df = 4; P = 0.0006), 80 µL (t = 22.16; df = 4; P < 0.0001) and

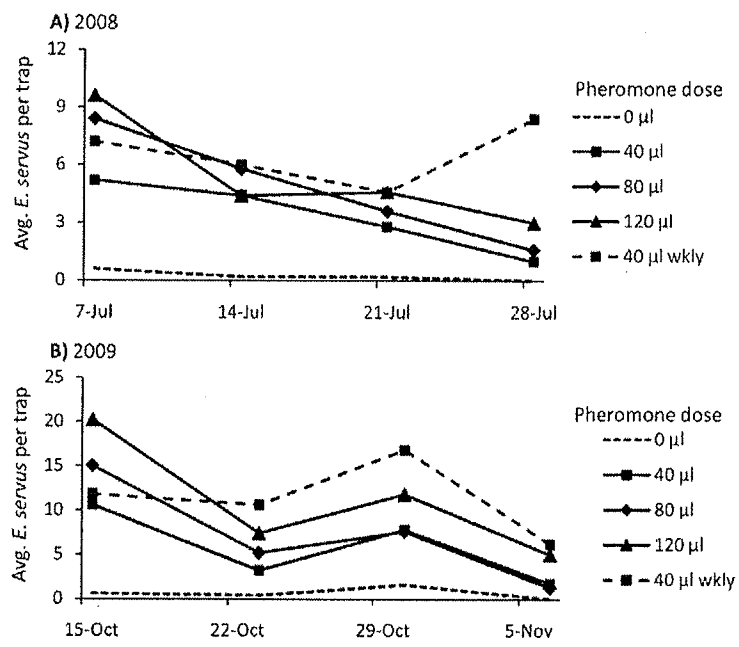

Fig. 3. Weekly capture of *Euschistus servus* adults during A) 2008 and B) 2009 in yellow pyramid traps baited with dispensers containing different doses of the *Euschistus* spp. aggregation pheromone loaded onto rubber septa. Dispensers were not changed weekly except for one dispenser with a dose of 40 µL.

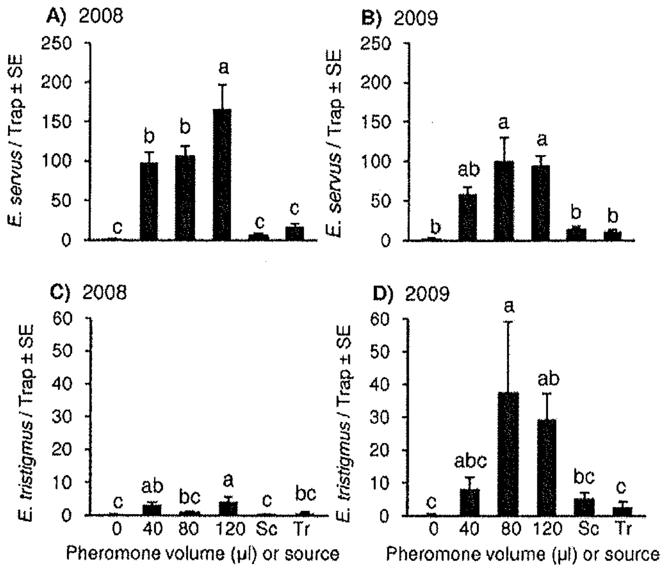

Fig. 4. Mean capture of A, B) *Euschistus servus* and C, D) *E. tristigmus* in yellow pyramid traps over a 4-wk interval from 11 June to 9 July 2008 and 16 September to 14 October 2009 using dispensers, i.e., rubber septa, loaded with different doses (0, 40, 80 or 120 µL) of pheromone and dispensers from commercial sources. Dispensers were replaced weekly except for Sc and Tr dispensers which were not replaced during the study. Sc; Scenturion, Tr; Trece.

120 µL (t = 27.60; df = 4; P < 0.0001) dispensers but also significantly less for the Trece dispenser that remained in the field for 4 wk (t = 3.19; df = 4; P = 0.0331). Average percentage weight loss (± SE) for these dispensers was 1.67 ± 0.17, 3.16 ± 0.14, 5.49 ± 0.19 and 1.17 ± 0.34, respectively. In contrast, the 0 µL dispenser (changed weekly) and the Scenturion dispenser (not changed weekly) were significantly heavier (t = -2.93; df = 4; P = 0.0428 and t = -5.12; df = 4; P = 0.0069, respectively) with average weight gains of 0.47 ± 0.16 and 1.21 ± 0.26%, respectively.

Experiment 4. Even when all dispensers (0, 40, 80, 120 µL, Scenturion and Trece) were changed weekly, a difference was detected between treatments during both 2008 and 2009 for captured *E. servus* stink bugs (F = 10.32; df = 5, 59; P = 0.0045 and F = 10.96; df = 5, 29; P = 0.0257, respectively). During 2008, only traps baited with the 120 µL dispensers captured significantly more *E. servus* than both the Scenturion and Trece lures; traps baited with commercial dispensers and 40 or 80 µL of pheromone captured similar numbers (Fig. 5A). Only the commercial dispensers did not capture significantly more *E. servus* stink bugs than the control treatment. A similar trend in trap capture was detected during 2009 except that this time, traps baited with 80 µL dispensers captured more stink bugs than either commercial dispenser (Fig. 5B). Additionally, similar numbers of *E. servus* were captured when using either commercial lure, the 40 µL dispenser or the control lure. A significant treatment effect also was found for *E. tristigmus* during 2008 and 2009 (F = 6.59; df = 5, 59; P = 0.0001 and F = 2.83; df = 5, 29; P = 0.0435, respectively). During 2008, the 120 µL dispenser

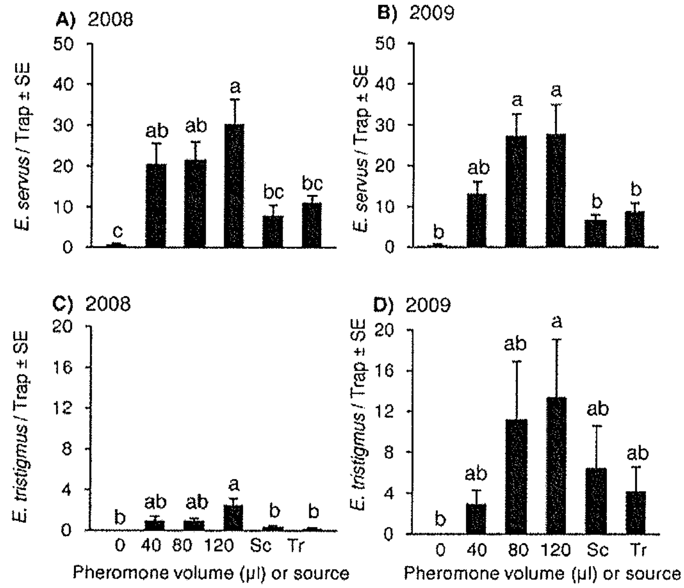

Fig. 5. Mean capture of A, B) *Euschistus servus* and C, D) *E. tristigmus* in yellow pyramid traps over a 4-wk interval from 5 August to 2 September 2008 and 16 September to 14 October 2009 using dispensers, i.e., rubber septa, loaded with different doses (0, 40, 80 or 120 µL) of pheromone and dispensers from commercial sources. All dispensers were replaced weekly. Sc; Scenturion, Tr; Trece.

captured significantly more *E. tristigmus* than either of the commercial or control dispensers (Fig. 5C). However, in 2009 the only significant difference was that the 120 µL dispenser captured more *E. tristigmus* than the control lure; no other dispenser resulted in trap capture higher than the control (Fig. 5D).

After 1 wk in the field, dispenser ending weight was significantly less than beginning weight for the 40 µL (t = 9.09; df = 19; P < 0.0001), 80 µL (t = 9.39; df = 19; P < 0.0001) 120 µL (t = 15.82; df = 19; P < 0.0001) and Trece (t = 2.93; df = 19; P < 0.0086) lures. Mean percentage weight loss (±SE) for these dispensers was 1.52 ± 0.18, 3.10 ± 0.33, 5.83 ± 0.37 and 1.02 ± 0.36, respectively. Although ending weight was not significantly different from beginning weight for the 0 µL (t = -1.92; df = 19; P = 0.0695) and Scenturion dispensers (t = -0.50; df = 19; P = 0.6246), each of these dispensers gained weight (0.52 ± 0.27 and 0.09 ± 0.18%, respectively) while in the field.

Experiment 5. When only the 2 commercial dispensers and the 40 µL dispenser were compared, with traps separated by 122 m and dispensers changed weekly, a significant difference in trap capture of *E. servus* was detected during 2008 and 2009 (F = 5.80; df = 2, 14; P = 0.0278 and F = 6.80; df = 2, 14; P = 0.0188, respectively). The 40 µL dispenser captured more *E. servus* than the Trece dispenser during both 2008 and 2009 (Fig. 6 A, B) but only captured more *E. servus* than the Scenturion dispenser during 2009 (Fig. 5 A, B). With regard to *E. tristigmus*, a significant difference in trap capture was detected during 2008 but not during 2009 (F = 4.58; df = 2, 14; P = 0.0472 and F = 0.17; df = 2, 14; P = 0.8484, respectively). More *E. tristigmus*

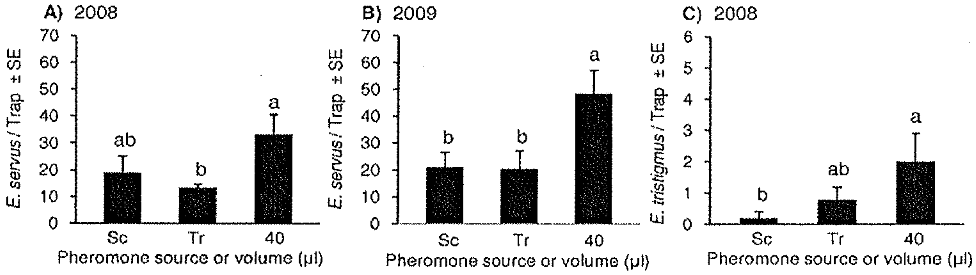

Fig. 6. Capture of A, B) *Euschistus servus* (5 August to 2 September 2008 and 2 September to 30 September 2009) and C) *E. tristigmus* (2 September to 30 September 30 2009) in yellow pyramid traps using two commercial dispensers or one laboratory prepared dispenser using 40 µL of pheromone. All dispensers were replaced weekly. Sc; Scenturion, Tr; Trece.

were captured during 2008 in traps baited with the 40 µL dispenser than the Scenturion dispenser (Fig. 6 C).

Ending weights for the 40 µL and Trece dispensers averaged 1.73 ± 0.27 and 1.10 ± 0.07%, respectively, less than beginning weights which represented a significant difference (t = 6.24; df = 4; P = 0.0034 and t = 13.993; df = 4; P = 0.0002, respectively). No difference was detected for beginning and ending weights of Scenturion dispensers (t = -2.32; df = 4; P = 0.0811).

Discussion

More *E. servus* than *E. tristigmus* were captured in yellow pyramid traps baited with the *Euschistus* spp. aggregation pheromone. These results are similar to those reported by Cottrell et al. (2000), Leskey and Hogmire (2005) and Hogmire and Leskey (2006). In pecan orchards, *E. servus* and *E. tristigmus* tend to separate vertically with more *E. servus* captured in pheromone-baited traps placed on the ground than in the pecan canopy and vice versa for *E. tristigmus* (Cottrell et al. 2000). Cottrell (2001) captured more *E. tristigmus* than *E. servus* in baited traps within a pecan orchard, but in that study no traps were suspended in the pecan canopy for comparison. Lower numbers of *E. tristigmus* captured during the current study were due, at least in part, to placement of traps on the ground. When pheromone traps have been used to sample *E. servus* and *E. tristigmus* all year, Cottrell et al. (2000) showed that capture of both species occurred from March to December with *E. servus* trap captures peaking in June and October and *E. tristigmus* capture peaking only during September. Phillips and Howell (1980) reported 2 generations of both *E. servus* and *E. tristigmus* developed from May to October in central Georgia apple orchards. In the current study, a particular test may have been conducted earlier in the season in 2008 than it was during 2009, but both trials occurred when stink bugs were available in the field.

Our results, along with previous research, show that attraction of *E. servus* and *E. tristigmus* to yellow pyramid traps is improved by the addition of the aggregation pheromone methyl (E,Z)-2,4-decadienoate to traps. A lure, prepared with any pheromone dose (e.g., 20 - 120 µL), resulted in a numerical increase of both *E. servus* and *E. tristigmus* captured in traps compared with traps without pheromone. In each experiment for each species, at least one pheromone dose significantly increased trap capture compared with traps without pheromone. Numerically higher trap captures associated with higher pheromone doses were not always significant for either species further suggesting that stink bug capture in pheromone-baited traps was likely affected by other factors.

Although this aggregation pheromone is attractive to *E. servus* and *E. tristigmus*, bugs may become arrested on vegetation near baited traps and not enter traps (Krupke et al. 2001, Leskey and Hogmire 2007). Even though bugs may have alighted on potted mullein (*Verbascum thapsus* L.) plants near traps, trap capture was unaffected by the presence or absence of plants near traps (Leskey and Hogmire 2007). When nearby vegetation occurred in our study, it consisted of low vegetation that had been mowed or pecan tree trunks, no closer to the trap than 3 m, with a canopy overhead. We did not sample for bugs on low vegetation or pecan trunks, as our intent was to investigate capture in traps with different pheromone doses and dispenser sources under conditions similar to commercial orchard settings. And even when stink bugs do enter jar tops, escape from the top is possible, but trap capture is enhanced through the addition of an insecticidal ear tag (Cottrell 2001) or by using a smaller jar top opening (Hogmire and Leskey 2006). The traps and jar tops used in this study were the same across treatments and all were provisioned with an insecticidal ear tag, making it unlikely that trap design was important regarding any differences in trap capture.

Using traps baited with the *Euschistus* spp. pheromone, Cullen and Zalom (2006) found that females entering traps were reproductively active, having mature eggs or actively ovipositing. In contrast, females collected from the same vicinity via plant-beating samples had ovaries in all categories of reproduction from undifferentiated ovariole chambers and no visible eggs to ovaries and eggs being degenerated. Although we did not use other methods to sample stink bugs around traps, early and late season captures in traps have previously revealed *E. servus* females at all stages of reproduction (TEC, unpubl. data).

Wall and Perry (1980) indicate that wind direction can play a role in trap capture of *Cydia nigricana* (F.) (Lepidoptera: Tortricidae). We placed replicates of traps in straight lines without respect to predominant wind direction and the treatments within replicates were always randomized. If any of the replicates of traps happened to be aligned with respect to the predominant wind direction, there is a remote possibility that the first trap (upwind) and the last trap (downwind) would have captured more stink bugs than the middle traps. Wall and Perry (1980) reported that 5 equally spaced traps in a straight line had higher capture of *C. nigricana* at the extreme upwind and downwind traps than in the middle traps. If this happened in the current study where treatments were randomized within each replicate, it possibly could have reduced our ability to detect differences in capture of stink bugs based solely upon pheromone dosage.

Spatial distribution of stink bugs within orchards and near orchard edges could have affected trap capture in the current study. Reay-Jones (2010) reported considerable levels of spatial variability in stink bug densities in wheat fields, including an edge effect where higher numbers of bugs were sampled. Likewise, Tillman et al. (2010) showed an edge effect when stink bugs moved from peanuts and aggregated in cotton at the interface of the two crops. Differences in habitats bordering test orchards and an uneven distribution of stink bugs across the landscape might contribute to similar trap captures in some instances where bugs responded to nearest traps and not specifically to traps with higher pheromone doses.

As a stink bug sampling tool, the pheromone-baited trap is capable of detecting changes in stink bug abundance. Given the mobility of adult stink bugs, it is unlikely that stink bugs would be trapped out of an area. Thus, the utility of this stink bug trapping system may lie in using it as a barrier, encircling orchards to reduce overwintering or new-generation stink bugs from moving into orchards. Additionally, it may be possible to use this trapping system in conjunction with a trap crop for management of other pest stink bug species not attracted to the trap (McPherson and Newsom 1984, Tillman 2006, Smith et al. 2009). But not all orchard sites or growers are amenable to space and maintenance requirements for trap crops and this trapping system may provide a means to potentially manage an otherwise difficult pest, e.g., *E. servus*, especially in southeastern peach orchards. Presence of the pheromone increases trap capture over nonbaited traps and increasing the pheromone dose in the dispenser may increase trap capture, but these numbers may not be significantly higher than capture using lower doses. Cumulative capture over time was similar to capture when dispensers were changed weekly, which may negate the importance of weekly bait changes, thus increasing the economy of this tactic against *Euschistus* spp. stink bugs moving into orchards by decreasing dispenser costs and labor expenditures for dispenser replacement. However, spacing between traps in concert with both the pheromone dose and attractive duration of dispensers needs to be investigated along with stink bug density and fruit damage sampling in orchards where this tactic is used.

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