COLLECTION OF FALL ARMYWORM (LEPIDOPTERA: NOCTUIDAE) ADULTS AND NONTARGET HYMENOPTERA IN DIFFERENT COLORED UNITRAPS

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ABSTRACT

Field experiments were conducted to determine the effectiveness of different colored pheromone-baited traps in capture of Fall Armyworm, *Spodoptera frugiperda*, males and nontarget Hymenoptera. Plastic Universal Moth Traps (Unitraps) of different colors were baited with commercial sex pheromone and were placed in peanut and corn fields in northern Florida. In one study, standard-colored (green canopy, yellow funnel, white bucket) traps collected more moths than all-white or all-green traps. More Sphecoidea were found in white traps while more Vespoidea were collected in standard traps. In another study, trap capture was compared among standard, all-white, and standard traps with buckets painted two different yellow colors. Results showed that there were few differences in capture among traps with different colors, however, contrasts between traps with yellow buckets or traps with white buckets suggested more moths could be captured in yellow-bucket traps. Very few Hymenoptera were collected, although more Apoidea were found in white traps.

Key Words: insect behavior, *Spodoptera*, monitoring, pheromone traps, Hymenoptera

RESUMEN

Experimentos de campo fueron conducidos para determinar la efectividad de trampas de distintos colores con señuelo de feromona para capturar al machos del gusano *Spodoptera frugiperda*, y miembros de Himenóptera. Trampas Plásticas Universales de Mariposa (Unitraps) de colores diferentes fueron preparadas con señuelo de feromona comercial de sexo y colocadas en campos de maíz y maní en el norte de Florida. En un estudio, trampas de color estándar (toldo verde, embudo amarillo, cubeta blanca) colectaron mas mariposas que trampas de color blanco o verde solamente. Mas Sphecoidea fueron encontrados en trampas blancas mientras que más Vespoidea fueron colectados en trampas estándar. En otro estudio, captura por trampa fue comparada entre estándar, blanca, y trampas estándar con cubetas pintadas con dos colores amarillos diferentes. Los resultados demuestran que hubo poca diferencia en capturas entre trampas con diferentes colores, sin embargo, contrastes entre trampas con cubetas amarillas o trampas con cubetas blancas sugirieron que más mariposas pueden ser capturadas con trampas de cubeta amarilla. Muy pocos Himenóptera fueron colectados, aunque mas Apoidea fueron encontrados en trampas blancas.

Traps for insect pests can be categorized into those that catch insects randomly (interception or passive traps such as Malaise, sticky pane, or pitfall traps) and those that attract and elicit orientating behavior (active traps such as light or baited traps) (Southwood 1978). Traps that attract insects use visual cues (yellow sticky cards, yellow pans, red spheres, etc.), chemical cues (pheromones, kairomones), edible baits, or any combination of the three. Workers involved in pest management research have developed traps that combine visual and chemical cues to attract insects, such as the work conducted with tephritids (Robacker et al. 1990, Stark & Vargas 1992, Epsky et al. 1995).

Few studies have documented the influence of visual cues in monitoring of noctuid moths. Decoys (dead female moths) were shown to improve capture of *Helicoverpa zea* (Boddie) males in electrocutor grid and sticky traps (Gross et al. 1983). Trap color has been shown to be important in the collection of several noctuids such as *Heliothis virescens* (F.) (Hendricks et al. 1972), *Anticarsia gemmatalis* Hübner (Mitchell et al. 1989), *Agrotis ipsilon* (Hufnagel), and *Pseudaletia unipuncta* (Haworth) (Hendrix & Showers 1990). Plastic bucket traps with green canopies, yellow funnels, and white buckets collected more *Spodoptera* spp. males than all-green traps in several studies (Mitchell et al. 1989; Pair et al. 1989; Lopez 1998). All-white traps are also commercially available, but have not been bioassayed for Fall Armyworm, *S. frugiperda* (J. E. Smith) capture. My studies were designed to compare capture of Fall Armyworm males using the same chemical cue (commercially available sex pheromone) but different visual cues (trap colors).

Few studies have documented the species and number of nontarget Hymenoptera that are captured in traps intended for agricultural lepi-

dopteran pests. Meagher & Mitchell (1999) found species from Apoidea, Pompiloidea, Scolioidea, Sphecoidea, and Vespoidea in traps using sex pheromone and synthetic floral volatiles as lures, however, all traps used white buckets. Because of the deleterious effect on foraging pollinators and natural enemies (Meagher & Mitchell 1999), and the increased time required to service traps containing these insects (Gross & Carpenter 1991), an additional objective of this study was to collect and identify nontarget aculeate Hymenoptera attracted to different trap colors.

Materials and Methods

1998

Peanuts (*Arachis hypogaea* L.,'Georgia Green') were planted during summer in northwestern Alachua County, Florida. This experiment was designed to compare moth and aculeate Hymenoptera capture in three Universal Moth Trap (Unitrap) (Great Lakes IPM, Vestaburg, MI) colors (all white, all green, or standard = green canopy, yellow funnel, white bucket). Traps were placed along roads and edges in two fields, and the experiment was designed as a randomized complete block with four replications of the three trap colors. Trap location within a replication was randomized weekly, and trapping began 21 July and ended 30 September. Both Trécé® (Trécé, Inc., Salinas, CA) red septa and Scentry® (Ecogen, Inc., Langhorne, PA) gray septa *S. frugiperda* pheromone lures were used. These lures were alternated and replaced every two weeks. All traps contained insecticide strips (Hercon® Vaportape II containing 10% dichlorovos, Hercon Environmental Co., Emigsville, PA) to kill captured insects. Trap contents were removed three or more times per week. Moth numbers per night and Hymenoptera numbers per day were compared across trap colors using a split-block analysis of variance (ANOVA) (Steel & Torrie 1980). To satisfy ANOVA assumptions, counts were *log* (x + 1) transformed before analysis. Means for each trap color were separated using a LSD mean separation test (SAS Institute 1996). Untransformed means (±SE) are given in text and figures, whereas statistical results refer to transformed data.

1999

Four different trapping treatments were placed at the University of Florida, Hastings Research and Education Center's Yelvington Farm, St. John's County during July and August. The four trap colors were standard, white, and standard traps with buckets spray painted Fluorescent Yellow (Painter's Touch #1942, Rust-Oleum Corp., Vernon Hills, IL) or Sun Yellow Gloss (Painter's Touch #1945). Traps were placed along roads among large plots of silage corn (*Zea mays* L.). The experiment was designed as a randomized complete block with four replications of the four trap colors. Trap location within a replication was randomized weekly, and trapping began 13 July and ended 19 August. Scenturion® (Scenturion Inc., Clinton, WA) gray septa Fall Armyworm pheromone lures were used, and were replaced every two weeks. All traps contained Vaportape II insecticide strips to kill moths that were captured. Trap contents were removed three or more times per week. Moth numbers per night and Hymenoptera numbers per day were compared across trap colors using a split-block ANOVA with *log* (x + 1)-transformed data. Means for each trap color or each trap color combination were separated using a LSD mean separation test or orthogonal contrasts (PROC GLM, CONTRAST statement, SAS Institute 1996).

Results

1998

Adult male Fall Armyworm numbers in the trap samples were high during July and August, and gradually decreased during September (Fig. 1). Comparison of moth captures among three trap colors showed that the standard traps captured significantly larger numbers of moths in 20 of 37 sampling dates. Most of the sampling dates where standard traps captured larger numbers of moths were during July and August, when traps were collecting over 50 moths per night. Only three sampling dates in September produced significant differences among traps. The overall average showed that standard traps captured more moths than white traps; green traps caught the fewest number of moths (54.0 ± 4.0, 24.1 ± 1.8, 11.9 ± 1.2 moths per night, respectively) ($F = 51.2$; df = 2, 6; $P = 0.0002$).

Collection of nontarget bees and wasps, both in number of individuals and number of species, was lower than previously documented (Fig. 2) (Meagher and Mitchell 1999). Species collected included *Melissodes* sp., *Apis mellifera* (L.), *Bombus pennsylvanicus* (De Geer), *Campsomeris plumipes fossulana* (F.), *Cerceris bicornuta* Guérin, *Ammophila* spp., and *Polistes* spp. More Sphecoidea were collected in white traps than standard or green traps ($F = 7.3$; df = 2, 6; $P = 0.0249$); more Vespoidea were collected in standard traps ($F = 4.1$; df = 2, 6; $P = 0.0743$) (Fig. 3). There was a trend toward fewer Apoidea in green traps.

1999

Consistently large numbers of Fall Armyworm males were collected in July and August from the surrounding corn fields (Fig. 3). There were no differences in number of males per night collected

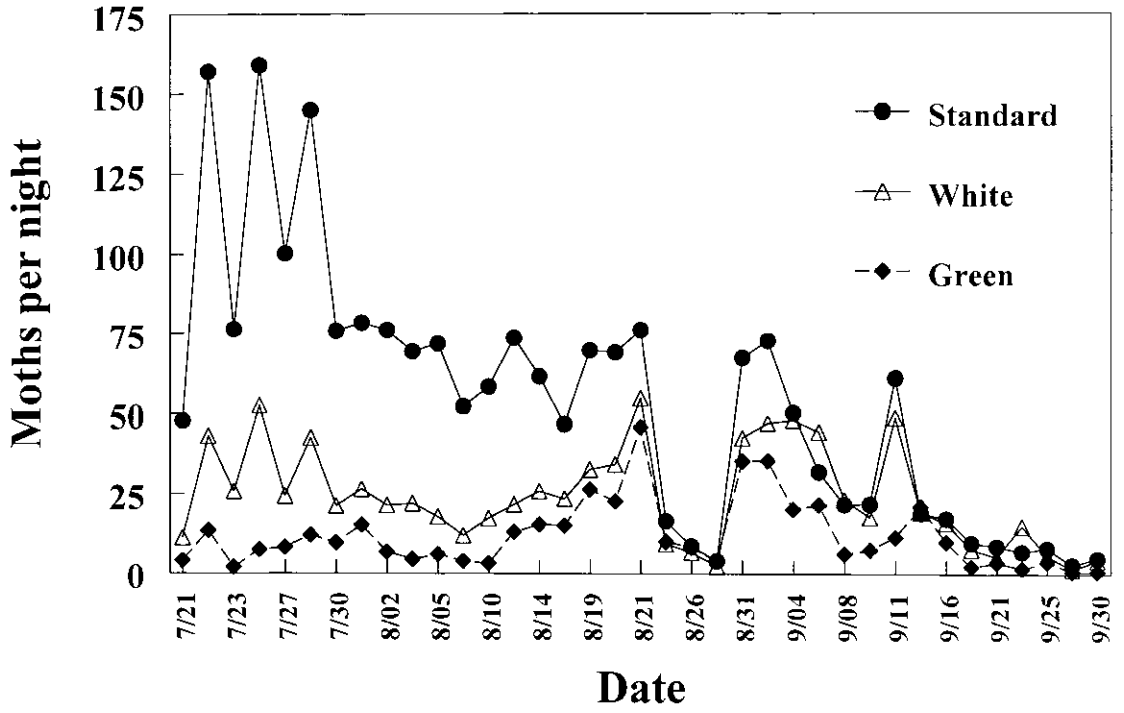

Fig. 1. Capture of male Fall Armyworm in standard (green canopy, yellow funnel, white bucket), all-white, or all-green Unitraps baited with sex pheromone lures, Alachua, FL, 1998.

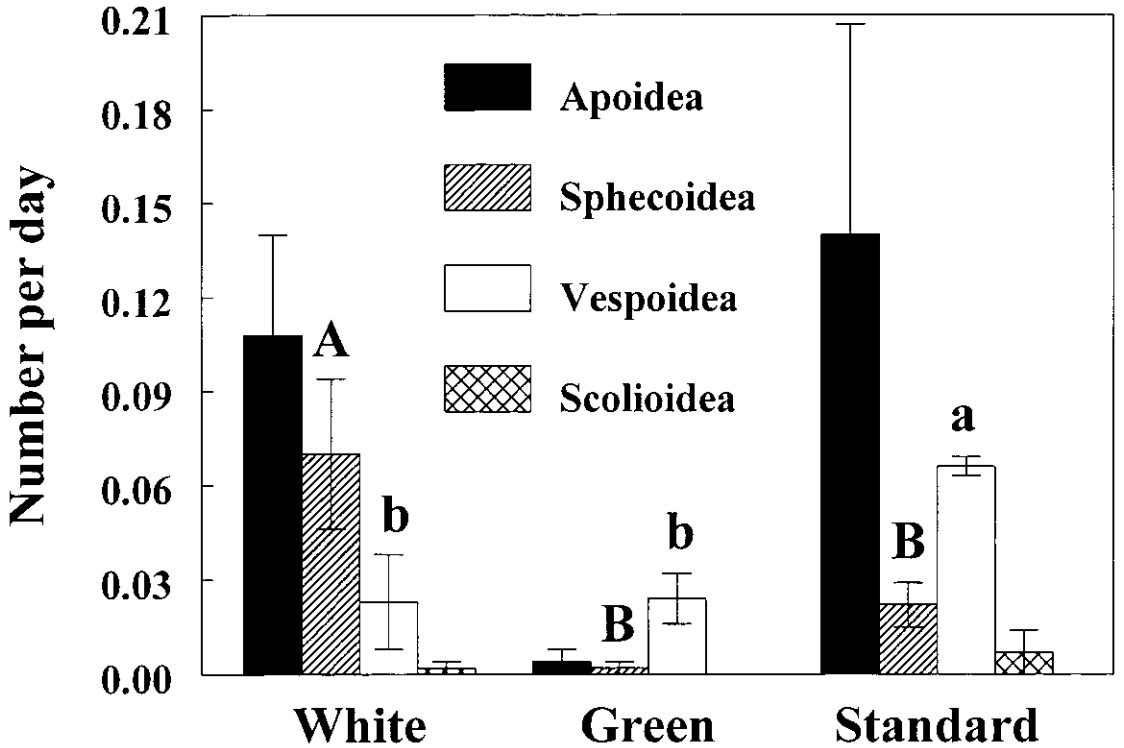

Fig. 2. Number of aculeate Hymenoptera captured per day in Fall Armyworm pheromone lure bucket traps in peanut, Alachua, FL, 1998. Means within Sphecoidea followed by the same uppercase letter and Vespoidea followed by the same lowercase letter, are not significantly different.

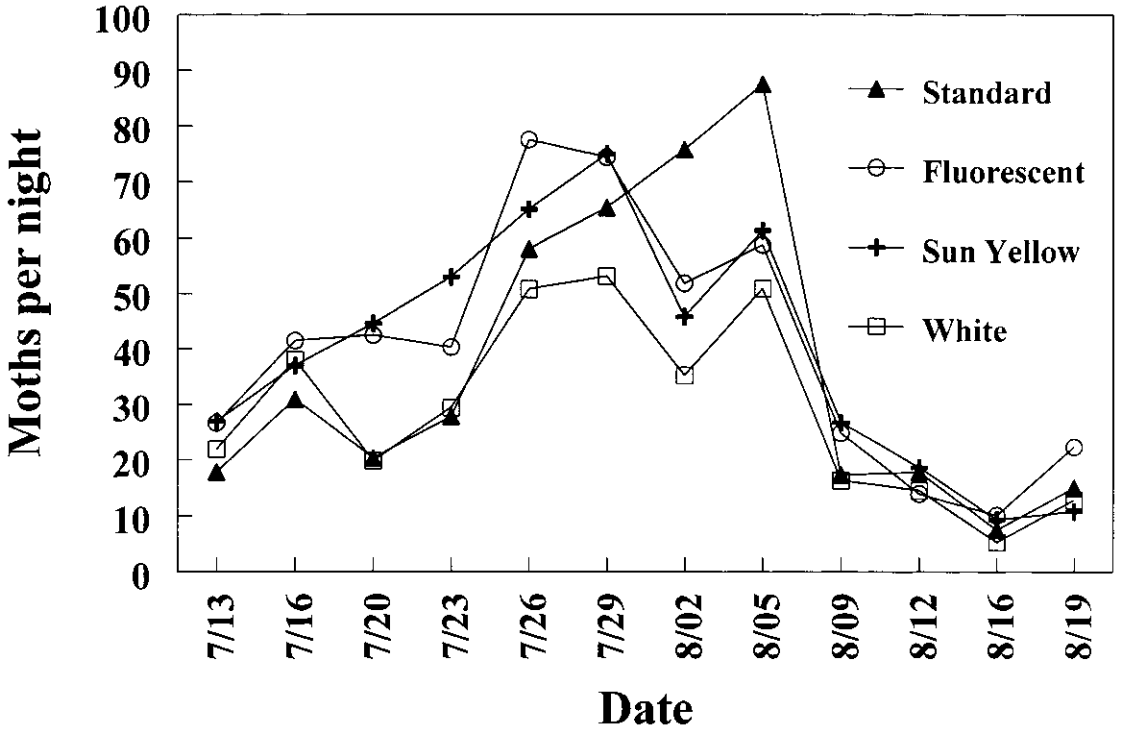

Fig. 3. Capture of male Fall Armyworm in standard (green canopy, yellow funnel, white bucket), fluorescent (green canopy, yellow funnel, fluorescent yellow bucket), sun yellow (green canopy, yellow funnel, sun yellow bucket), or all-white Unitraps baited with sex pheromone lures, Hastings, FL, 1999.

in traps with different colors when analyzed across dates (fluorescent yellow 40.4 ± 4.2, sun yellow 39.5 ± 4.6, standard 36.7 ± 4.7, white 29.0 ± 3.3; $F = 2.7$; df = 3, 9; $P = 0.1089$). When each of the 12 dates was analyzed separately, only 2 dates (20 July, 2 August) had differences in males captured among all trap colors ($P < 0.05$). However, when different trap color combinations were subjected to contrasts, differences in capture were noted. Generally, traps with yellow buckets (fluorescent yellow and sun yellow traps) captured more moths than traps with white buckets (standard and white traps), and all-white traps collected fewer moths (Table 1).

Very few Vespoidea, Sphecoidea, Tiphioidea, and Scolioidea were collected. Since more *Bombus* spp. were collected, their numbers were analyzed separately from other species of Apoidea. More Apoidea were collected from white traps than the other traps, whereas there were no differences among trap colors in collection of *Bombus* spp. (Fig. 4).

TABLE 1. CONTRAST OF NUMBERS OF FALL ARMYWORM MALES CAPTURED BETWEEN TRAPS WITH DIFFERENT COLORED BUCKETS, HASTINGS, FL, 1999

Contrast	*F*-value	Pr > *F*	N	Means ± SE
fluorescent + sun	7.4	0.0238	96	39.9 ± 3.1
vs. white			48	29.0 ± 3.3
fluorescent + sun	2.7	0.1350	96	39.9 ± 3.1
vs. standard			48	36.7 ± 4.7
fluorescent + sun	7.1	0.0257	96	39.9 ± 3.1
vs. standard + white			96	32.9 ± 2.9
fluorescent + sun + standard	5.3	0.0470	144	38.9 ± 2.6
vs. white			48	29.0 ± 3.3

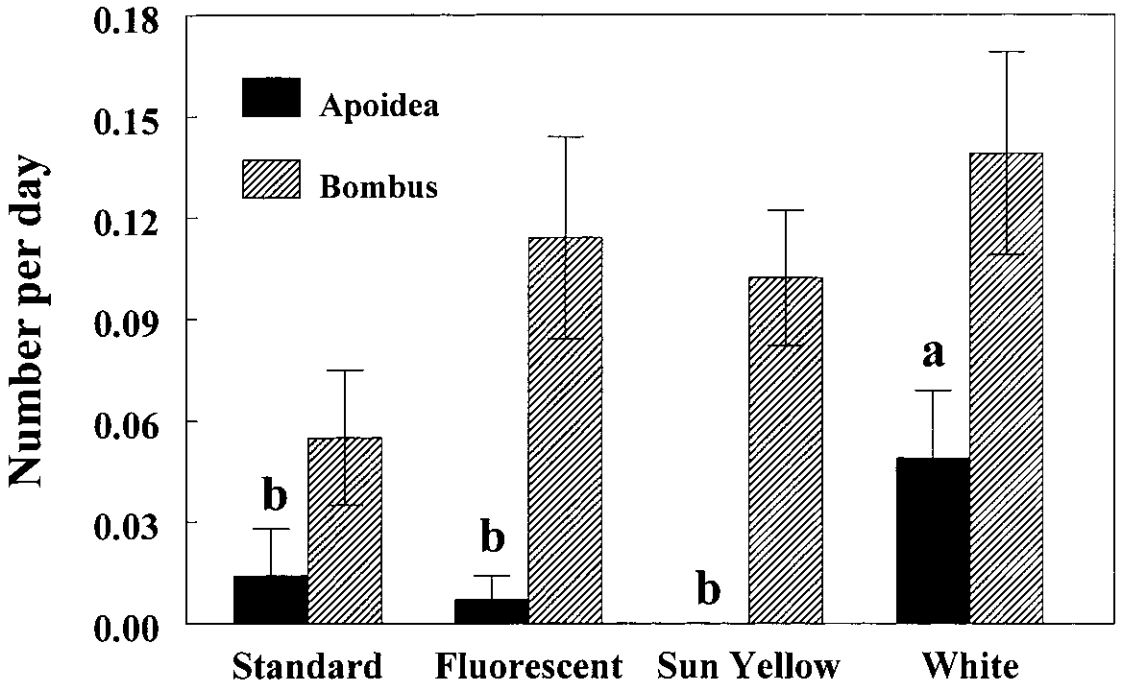

Fig. 4. Number of Apoidea and *Bombus* spp. captured per day in Fall Armyworm pheromone lure Unitraps in corn, Hastings, FL, 1999. Means within Apoidea followed by the same letter are not significantly different.

Discussion

Trap color was shown to influence Fall Armyworm capture in previous trials (Mitchell et al. 1989; Pair et al. 1989), however in those studies all-white traps and traps with yellow funnel and buckets were not compared. My results showed that more moths were collected in standard traps than all-white or all-green traps, a result similar to what has been documented with *S. exigua* (Hübner) (Lopez 1998). Spectral analysis of the white, yellow, and green components of bucket traps indicates a possible factor responsible for decreased capture of moths in green traps was low light reflectance at wavelengths where moth eyes are most sensitive (Mitchell et al. 1989). However, too much reflectance may decrease moth capture since all-white traps captured fewer moths than standard traps.

Traps composed of yellow funnels and buckets tended to collect more males than traps with white buckets, but differences were not significant on all dates. Spectral analysis showed higher reflectance for fluorescent yellow than sun yellow in the 500-560 nm range (unpublished data), although this difference appears not to have influenced trap capture. Therefore, if the objective of monitoring for Fall Armyworm is to collect the largest number of moths, than it can be concluded from this research and from previous research (Meagher & Mitchell 2001), that the standard Unitrap with green canopy, yellow funnel, and white bucket is the best collector of male Fall Armyworm when used with available commercial sex pheromones.

The attraction of *Bombus* spp. to traps using noctuid sex pheromone lures has been previously documented (Adams et al. 1989; Hendrix & Showers 1990; Gross & Carpenter 1991; Meagher & Mitchell 1999). Trap color seems to be important in the capture of bumblebees (Hamilton et al. 1971), although chemical cues either from the pheromone, the insecticidal strips, or both, may contribute to capture of these insects (Gross & Carpenter 1991). As far as capture of other aculeate Hymenoptera (Sphecoidea, Vespoidea, and Scolioidea) in different colored traps, very little has been documented.

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