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MONITORING FOR EXOTIC *SPODOPTERA* SPECIES (LEPIDOPTERA: NOCTUIDAE) IN FLORIDA

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ABSTRACT

Trapping studies were conducted in 2 Florida locations to determine if 3 Old World *Spodoptera* Guenée species were present. Commercially-produced lures for *S. exempta* (Walker), *S. littoralis* (Boisduval), and *S. litura* (F.), plus a *S. litura* lure made by the USDA-APHIS-CPHST laboratory at Otis ANGB in Massachusetts, were used with plastic Unitraps and placed near 2 orchid nurseries in Lake and Miami-Dade counties. One *S. litura* male moth was identified from collections made in Apr 2007; no other exotic species were found in either location. However, thousands of resident species were collected, including *S. albula* (Walker) (= *S. sunia* Guenée), *S. dolichos* (F.), *S. eridania* (Stoll), *S. exigua* (Hübner), (J. E. Smith), and *S. pulchella* (Herrich-Schäffer). This study exposed the amount of labor and level of technical knowledge needed for scientists involved in finding exotic *Spodoptera* species.

Key Words: *Spodoptera*, pheromones, trapping, orchid nurseries, exotic species

RESUMEN

Se llevaron a cabo estudios de monitoreo en dos localidades en Florida para detectar la presencia de tres especies exóticas de *Spodoptera* del hemisferio Este. Se usaron cebos comerciales para las especies de *S. exempta* (Walker), *S. littoralis* (Boisduval), y *S. litura* (F.), además de un cebo de *S. litura* fabricado por el laboratorio Otis ANGB de USDA-APHIS-CPHST en Massachussetts. Se utilizaron trampas de plástico « Unitraps », las cuales se instalaron cerca de dos viveros de orquídeas en los condados de Lake y Miami-Dade. Un especimen macho de *S. litura* fué identificado en un muestra de abril 2007. Ninguna otra especie exótica fué encontrada en las dos localidades. Sin embargo, miles de especímenes nativos fueron atrapados de las especies *S. albula* (Walker) (= *S. sunia* Guenée), *S. dolichos* (F.), *S. eridania* (Stoll), *S. exigua* (Hübner), *S. frugiperda* (J. E. Smith), y *S. pulchella* (Herrich-Schäffer). Este proyecto expuso la gran cantidad de trabajo requerido y el nivel de conocimiento técnico necesario de los investigadores para detectar especies exóticas de *Spodoptera*.

The armyworm genus *Spodoptera* Guenée (Noctuidae: Amphipyrinae) contains 30 species that inhabit 6 continents (Pogue 2002). Species in temperate North America include several agricultural pests such as *S. eridania* (Stoll) (southern armyworm, Liburd et al. 2000), *S. exigua* (Hübner) (beet armyworm, Chen et al. 2008), *S. frugiperda* (J. E. Smith) (fall armyworm, Nagoshi & Meagher 2004), *S. latifascia* (Walker) (Vergara & Pitre 2001), *S. ornithogalli* (Guenée) (yellowstriped armyworm, Liburd et al. 2000), and *S. praefica* (Grote) (western yellowstriped armyworm, Summers 1989). These species feed on a wide range of grain, row, forage, vegetable, and ornamental crops. Four other species, *S. albula* (Walker) (= *S. sunia* Guenée), *S. androgea* (Stoll), *S. dolichos* (F.), and *S. pulchella* (Herrich-Schäffer) are present in the USA and in Neotropical regions of the Western Hemisphere (Pogue 2002). The beet armyworm is the only cosmopolitan species in the genus (Pogue 2002), and is probably Palaearctic in origin. The western yellowstriped armyworm is restricted to the western United States in distribution (Pogue 2002).

The Eastern Hemisphere contains 3 species that are serious agricultural pests. *Spodoptera exempta* (Walker), the nutgrass armyworm or African armyworm, is a migratory pest of cereal and pasture grasses (Cheke & Tucker 1995) that inhabits southern Europe, the Ethiopian Region, the Australasian Region, and various South Pacific islands including Hawaii (Pogue 2002). *Spodoptera littoralis* (Boisduval), the Egyptian cotton leafworm, is a pest of cotton (Amin & Gergis 2006) and other agricultural crops. It ranges from southern Europe and Africa through the Middle East and western Asia and several islands in the Indian Ocean. *Spodoptera litura* (F.) (to-

bacco cutworm, cluster caterpillar, and rice cutworm, among other common names) attacks a wide range of crops including cotton, peanuts (groundnuts), rice, soybeans, vegetables, and ornamental plants (EPPO/CABI 1997). This species also has a wide geographical range, inhabiting western Asia eastward through eastern Asia and southward to the Australasian Region (Pogue 2002). It is also found throughout the Pacific including Hawaii.

Florida is second in the USA in the value of nursery and greenhouse crops, reaching $1.63 billion in 2004 (Jerardo 2005). Orchids are the second leading potted flowering plant produced in Florida. Much of the production in Florida involves importing small plants, growing them in shade houses for 6-12 mo. and then shipping them to markets in the USA and Canada. Many of the hundreds of thousands of small plants are imported from locations in Asia (Thailand, Taiwan, and China) where *S. litura* is known as a pest.

Pheromone-baited traps provide a technique to monitor relatively large areas for the presence of moth species. Pheromone components or blends have been identified for many of the species currently in the USA, including *S. albula* (Bestmann et al. 1988—published as *S. sunia* Guenée), *S. dolichos* (Lalanne-Cassou et al. 1994), *S. eridania* (Mitchell & Tumlinson 1994; Teal et al. 1985), *S. exigua* (Deng et al. 2004; Jung et al. 2003; Mitchell & Tumlinson 1994), *S. frugiperda* (Tumlinson et al. 1986; Batista-Pereira et al. 2006), *S. latifascia* (Monti et al. 1995) and *S. praefica* (Landolt et al. 2003). Pheromone blends have been synthesized and are commercially available for *S. eridania*, *S. exigua*, *S. frugiperda*, and *S. praefica*.

Pheromone components and blends have been identified and are commercially-available for 3 of the agriculturally-important exotic *Spodoptera* species, *S. exempta* (Cork et al. 1989), *S. littoralis* (Dunkelblum et al. 1987; Malo et al. 2000), and *S. litura* (Sun et al. 2003; Wei et al. 2004). Many of the components that make up the blends are similar across species (Table 1), but are released in different ratios. Our objective for this research was to monitor for exotic *Spodoptera* species with pheromone-baited traps placed near orchid nurseries. A secondary objective was to determine which native species would be attracted to these lures so that identification of moths could be made.

Materials and Methods

Groveland

The field site was located outside of Groveland, FL (Lake County) and was composed of shade houses (52,000 m^2) surrounded by mixed natural vegetation and small home sites. The shade houses contained over 2 million plants, including *Cymbidium*, *Dendrobium*, and *Phalenopsis* orchids. The orchids are imported from Asia as young plants and grown for 6-12 months. They are then shipped to retail stores across the U.S. and Canada.

Pheromone-baited standard Universal Moth Traps, "Unitraps" (Great Lakes IPM, Vestaburg,

Table 1. Pheromone components for selected Spodoptera species.

Species	Components	Reference
albula	*Z*9-14:Ac, *Z*9-14:OH, *Z*11-16:Ac, *Z*9,*E*12-14:Ac	Bestmann et al. 1988
dolichos	*Z*9-14:Ac, *Z*9,*E*12-14:Ac	Lalanne-Cassou et al. 1994
eridania	*Z*9-14:Ac, *Z*9,*E*12-14:Ac, *Z*11-16:A,*Z*9,*E*11-14:Ac	Teal et al. 1985; Mitchell & Tumlinson 1994
exempta	*Z*9-14:Ac, *Z*9,*E*12-14:Ac, *Z*11-16:Ac	Cork et al. 1989
exigua	*Z*9,*E*12-14:Ac, *Z*11-16:Ac, *Z*9-14:OH	Mitchell & Tumlinson 1994; Jung et al. 2003; Deng et al. 2004
	*Z*9,*E*12-14:Ac, *Z*9-14:OH	
	*Z*9,*E*12-14:Ac, *Z*9-14:OH	
frugiperda	*Z*9-14:Ac, *Z*7-12:Ac	Tumlinson et al. 1986; Batista-Pereira et al. 2006
	*Z*9-14:Ac, *Z*7-12:Ac, *E*7-12:Ac	
latifascia	*Z*9-14:Ac, *Z*9,*E*12-14:Ac	Monti et al. 1995
littoralis	*Z*9,*E*11-14:Ac	Dunkelblum et al. 1987; Malo et al. 2000
	*Z*9,*E*11-14:Ac, *Z*9-14:Ac, *E*11-14:Ac	
	14:Ac, *Z*11-14:Ac	
litura	*Z*9,*E*11-14:Ac, *Z*9,*E*12-14:Ac	Sun et al. 2003; Wei et al. 2004
	*Z*9,*E*11-14:Ac, *E*11-14:Ac, *Z*9,*E*12-14:Ac	
	*Z*9-14:Ac	

14:Ac = tetradecyl acetate; *E*7-12:Ac = (*E*)-7-dodecenyl acetate; *Z*7-12:Ac = (*Z*)-7-dodecenyl acetate; *Z*9-14:OH = (*Z*)-9-tetradecen-1-ol; *Z*9-14:Ac = (*Z*)-9-tetradecenyl acetate; *E*11-14:Ac = (*E*)-11-tetradecenyl acetate; *Z*11-14:Ac = (*Z*)-11-tetradecenyl acetate; *Z*11-16:Ac = (*Z*)-11-hexadecenyl acetate; *Z*9,*E*11-14:Ac = (*Z*,*E*)-9,11-tetradecadienyl acetate; *Z*9,*E*12-14:Ac = (*Z*,*E*)-9,12-tetradecadienyl acetate.

MI) were used to capture attracted male moths. These traps are constructed of a white bucket, a yellow cone on top of the bucket, and a dark green cover above the cone. Scenturion® pheromone lures (Suterra LLC, Bend, OR) for each species (*S. eridania*, *S. exempta*, *S. exigua*, *S. frugiperda*, *S. littoralis*, *S. litura*, and *S. praefica*) were attached to corks (#11) with a pin, and the cork was placed in the middle of the green cover. An additional lure for *S. litura* was provided by the USDA-APHIS CPHST laboratory at Otis ANGB, Cape Cod, MA. A 2.5 × 2.5 cm piece of Vaportape (Hercon Environmental, Emigsville, PA) releasing the pesticide dichlorvos was stapled to a string and hung inside the bucket to kill captured moths. Two rows of traps were placed outside of the shade houses on 1.5-m metal poles at least 30 m apart, and species order was randomized at each sample date. Traps were placed 25 Jan 2006 and samples were collected either biweekly or monthly until 2 Oct 2006. Pheromone lures and vaportape were replaced when traps were serviced. It was soon noticed that large numbers of honey bees were collected in the traps due to a small apiary less than 1 km east of the site. Therefore, green buckets were used on one row of traps closest to the apiary.

Homestead

This site was located southwest of Homestead, FL (Miami-Dade County) in a mixed agricultural and urban environment, and contained 26,000 m^2 of greenhouse space holding *Dendrobium*, and *Phalenopsis* orchids. One row of pheromone-baited traps for the same species as Groveland were placed on the south side of the complex on 24 Jan 2007 and removed 31 Oct 2007. Traps were serviced every 2 weeks and lures and vaportape were replaced monthly.

Moth Species Identification

Spodoptera species moths were identified with the keys and descriptions of Pogue (2002). The abdomen of all specimens was softened and cleared with hot 10% KOH. Genitalia were extracted with fine tweezers and various characters were examined under a dissecting microscope. The primary characters used for species identification were, not in order of importance, (1) number of coremata lobes and the shape of (2) clavus, (3) sacculus, (4) costal process, (5) basal sclerite of clasper, and (6) juxta.

RESULTS

Groveland

Pheromone lures for the 3 native species caught relatively few moths. The *S. exigua*-baited traps only attracted one beet armyworm moth, the *S. eridania*-baited traps attracted 13 southern armyworm moths and 1 *S. dolichos* moth, and the *S. frugiperda*-baited traps attracted 6 fall armyworm moths. The *S. praefica*-baited traps did not attract any *Spodoptera* species but did attract 2 Plusiinae moths, soybean looper *Chrysodeixis includens* (Walker) (10) and sharp-stigma looper *Ctenoplusia oxygramma* (Geyer) (6).

The lures for the exotic species were much more active in attracting moths. The *S. exempta*-baited traps attracted large numbers of *S. albula* (183) and *S. latifascia* (863), and both species were present throughout the trapping duration (Fig. 1). The 2 *S. litura*-baited traps caught much fewer moths. The Suterra blend only attracted 1 beet armyworm; the Otis ANGB blend only attracted 3 *S. dolichos*. Surprisingly, the *S. littoralis*-baited traps did not attract any moths for the entire season.

Homestead

Many more moths were collected at the Homestead location. The beet armyworm and fall armyworm lures attracted almost exclusively the target species, with 257 and 682 moths captured, respectively (Fig. 2). The southern armyworm lure attracted the target species (165), but attracted more nontarget *Spodoptera* species including *S. dolichos* (237) and *S. pulchella* (12) (Fig. 3). As at Groveland, the *S. praefica* lures did not attract any *Spodoptera* species but did attract soybean loopers (194).

Collections of moths on Apr 20 revealed 1 *S. litura* moth in the Suterra blend of the *S. litura* pheromone. This was the only exotic moth collected for either location. Otherwise, these traps only attracted 9 *S. dolichos* and 2 *S. pulchella*.

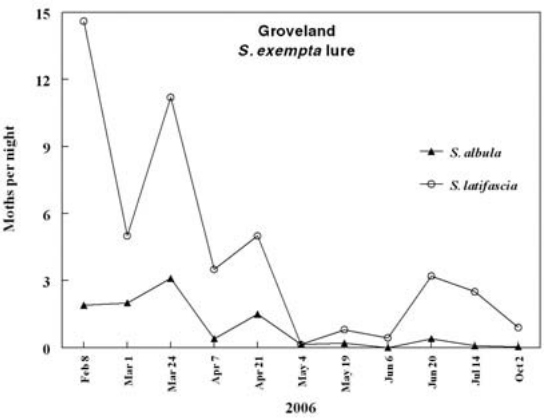

Fig. 1. Numbers of *Spodoptera albula* (Walker) and *S. latifascia* (Walker) adult males collected per night in Unitraps baited with a lure comprised of the sex pheromone blend of *S. exempta* (Walker), Groveland, FL, 2006.

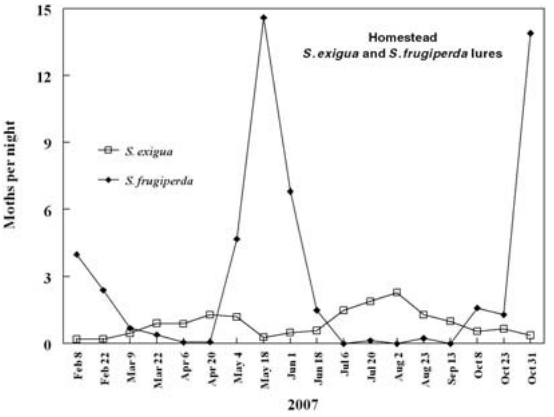

Fig. 2. Numbers of *Spodoptera exigua* (Hübner) and *S. frugiperda* (J. E. Smith) adult males collected per night in Unitraps baited with lures comprised of the sex pheromone blends for each species, respectively, Homestead, FL, 2007.

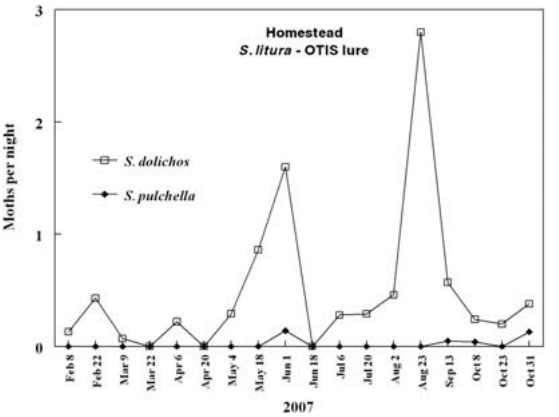

Fig. 4. Numbers of *Spodoptera dolichos* (F.) and *S. pulchella* (Herrich-Schäffer) adult males collected per night in Unitraps baited with a lure comprised of the sex pheromone blend of *S. litura* (F.) (Otis ANGB septa), Homestead, FL, 2007.

The Otis-ANGB blend attracted 149 *S. dolichos* and 5 *S. pulchella* (Fig. 4). The *S. exempta* baited-traps attracted thousands of native *Spodoptera* moths, including *S. albula* (1896), *S. latifascia* (1729) and *S. pulchella* (28). During May and Jun, over 15 *S. albula* moths per night were collected, whereas the final sampling date resulted in 30 *S. latifascia* moths per night (Fig. 5). As at Groveland, the *S. littoralis*-baited traps captured no *Spodoptera* species.

Discussion

The main objective of this work was to determine if any of the 3 exotic *Spodoptera* species were present. Although 1 *S. litura* male was found, subsequent intensive surveys with both pheromone lures have failed to collect moths (J. B., unpublished data). Tests are currently being conducted in India to determine the attractiveness of both blends in areas of natural *S. litura* populations. The 2 blends attracted different numbers of the native species *S. dolichos*. This apparently common species has (*Z*)9,(*E*)12-14:Ac and (*Z*)9-14:Ac as pheromone components (Lalanne-Cassou et al. 1994) and appears to be attracted to the 2 double-bonded acetate component that is in the Otis-ANGB blend.

It was somewhat surprising that the *S. littoralis* lures did not attract any *Spodoptera*

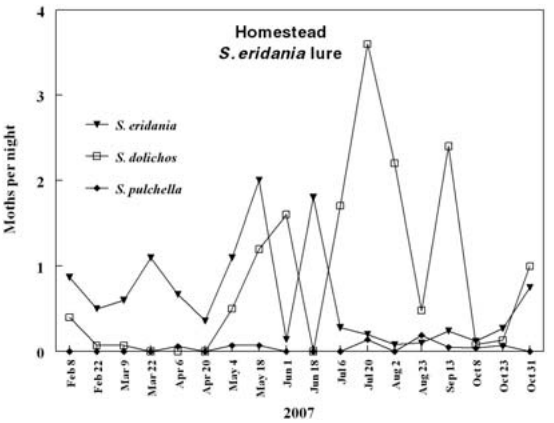

Fig. 3. Numbers of *Spodoptera eridania* (Stoll), *S. dolichos* (F.), and *S. pulchella* (Herrich-Schäffer) adult males collected per night in Unitraps baited with a lure comprised of the sex pheromone blend of *S. eridania*, Homestead, FL, 2007.

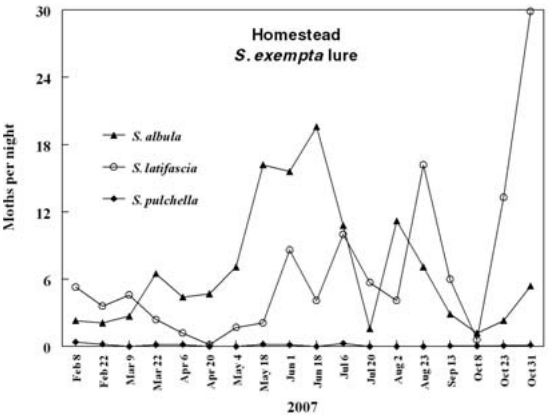

Fig. 5. Numbers of *Spodoptera albula* (Walker), *S. latifascia* (Walker), and *S. pulchella* (Herrich-Schäffer) adult males collected per night in Unitraps baited with a lure comprised of the sex pheromone blend of *S. exempta* (Walker), Homestead, FL, 2007.

moths, although the major component of the blend, (*Z*)9,(*E*)11-14:Ac (Dunkelblum et al. 1987; Malo et al. 2000), is not a major component for any of the native *Spodoptera* species. Previous tests in the Madeira Islands, Portugal, showed that these lures were effective in attracting *S. littoralis* moths (R. Pereira and J. B., unpublished data).

On the other hand, the large number of *S. albula* and *S. latifascia* moths attracted to the *S. exempta* lures agrees with the published reports of the pheromone blends for these species. The major component is (*Z*)9-14:Ac, with lesser amounts of (*Z*)9,(*E*)12-14:Ac and (*Z*)11-16:Ac (Bestmann et al. 1988; Cork et al. 1989; Monti et al. 1995). Commercial lures for *S. albula* and *S. latifascia* are not available, but it appears the lure for *S. exempta* could be used for these species.

Lures for the 3 Florida pest species, *S. eridania*, *S. exigua*, and *S. frugiperda* attracted the target moths. The *S. eridania* lures, however, attracted higher numbers of *S. dolichos* than the target species. Both species have (*Z*)9-14:Ac and (*Z*)9,(*E*)12-14:Ac as part of their pheromone blends (Lalanne-Cassou et al. 1994; Mitchell & Tumlinson 1994; Teal et al. 1985). The component (*Z*)9,(*E*)12-14:Ac is known to attract *S. dolichos* males (Mitchell & Tumlinson 1973). Cross attraction between *S. eridania* and *S. exigua,* which has been documented in other studies (Mitchell & Doolittle 1976; Mitchell & Tumlinson 1994), was rarely found in our study.

Because several native species were attracted to the blends designed for the 3 exotic species, moth identification will be critical to determining whether *S. exempta*, *S. littoralis*, or *S. litura* is intercepted or becomes established in Florida. Unless moths are retrieved quickly, noctuids captured in bucket traps over a period of several nights can be worn and difficult to identify based on forewing characters. Therefore, time-consuming identification with characters of the genitalia will need to be made. It is hoped that more entomologists can learn these characters and techniques to help identify this important group of pests.

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